Question 1. Electric field of charged disk

COULOMB; INTEGRATION

DISK OF CHARGE

a) Find the electric field a distance R along the axis from a disc of radius R_0 and uniform charge density σ. [Hint: a disk can be thought of as a bunch of concentric rings. Can you first find the E field a distance R along the axis up from a thin ring of charge dq?]

b) Explicitly calculate the limiting forms of your solution at very small and at very large R (compared to R_0) and discuss.

Note: The disk of charge is an idealization of many physical devices: a capacitor plate, a small patch of any surface... Once you have solved this ideal *problem, you will be able to apply it (many times this term!) to more realistic situations.*

Question 2. Angle between two suspended charges

COULOMB REPULSION

Two charges of mass m and charge q and $2q$ hang form strings of length l from a common point. Find the expression for the angle θ each makes with respect to the vertical.

Question 3. Charge density and E field of atmosphere

REALWORLD

6.* The electric field in the atmosphere at the earth's surface is approximately 200 V/m, directed downward. At 1400m above the earth's surface, the electric field in the atmosphere is only 20 V/m, again directed downward.

a) What is the average charge density in the atmosphere below 1400 m?

b) Does this consist predominantly of positive or negative ions?

Question 4. Electric field of charged sphere

COULOMB; INTEGRATION; ESTIMATION; REAL WORLD

a) Find the electric field a distance z from the center of a spherical surface of radius R (Fig 2.11 in Griffiths) which carries a uniform surface charge density σ. Do this by explicit integration (i.e. starting from Griffiths Eq. 2.7), please.

You only need to treat the case $z>R$ (*outside* the sphere). Express your answer in terms of the total charge q on the sphere.

[Hint: Use the law of cosines to write r in terms of R and θ. I got an integral which I needed to look up - do you have access to tables, or Mathematica, or some other such tool? In the end, be careful if you get a square root to take the *positive* root: $\sqrt{R^2+z^2-2Rz} = (R-z)$ if $R>z$, but it's $(z-R)$ if $R<z$].

You can use the following integral:

$$\int_{-1}^{1} \frac{z-Ru}{(R^2+z^2-2Rzu)^{3/2}}du = \left[\frac{1}{z^2}\frac{zu-R}{\sqrt{R^2+z^2-2Rzu}}\right]_{-1}^{1}$$

You might need to do a substitution of u=cos(θ)

b) Check your answer using knowledge from PHYS2425 and intuition (briefly discuss - what *should* it be?) What would you expect the answer should be *inside* the sphere? Why?
c) Estimate the maximum charge you can put onto a child's balloon that has a radius of 0.25 meter.
Why should there be a maximum at all? That's key: if the balloon sparks, it can bear no more charge. Can you look up the breakdown electric voltage of air somewhere?
*Your answer can be *very* rough, we only want an order of magnitude.*