Electric Fields Exam, Problems

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10/4

1 Finding Electric Fields

1.1 Progressive Derivations

(Note: this is the last problem from Week 7, Session 1 Problems in case you didn't get around to it. It is a good problem to know.)

This problem asks you to find the electric field from progressively more complex charge distributions. Indeed, part (c) seems very hard to solve for. [Hint: use the result of part (a) for part (b). Similarly, use the result of part (b) for part (c).]

(a) Suppose there is a ring of charge of radius r centered at the origin in the xy-plane with linear charge density λ. Calculate the field at a point P that is at $(x, y, z) = (0, 0, d)$.

(b) Suppose there is a disk of radius R centered at the origin in the xy-plane with area charge density σ. Calculate the field at the same point P.

(c) Suppose there is a a cylinder of radius R centered at the origin in the xy-plane with its bottom surface in that plane, extending a height h upwards along its axis, the z-axis. If this cylinder has charge density ρ, calculate the field at the same point P, assuming $h < d$.

2 Previous Midterm Problems

2.1 Non-Uniform Charge Distributions?!

A non-uniformly charged ring of radius R carries a linear charge density $\lambda(\theta)= \lambda_0 \cos(\theta)$, with $\lambda_0 > 0$. The ring lies in the (x, y) plane centered at the origin.

(a) Determine the direction of the electric field created at $(0, 0, z)$, and explain your reasoning.

(b) Calculate the magnitude of the field.

(c) A similar ring of linear charge density $\lambda(\theta)= -\lambda_0\cos(\theta)$ is placed at distance $2R$ from the first one along the symmetry axis. Determine the new field on the symmetry axis.

(d) Make a qualitative plot of the magnitude on axis of the electric field between the two rings.

(*Source: Bordel Spring 2013 Midterm 2*)

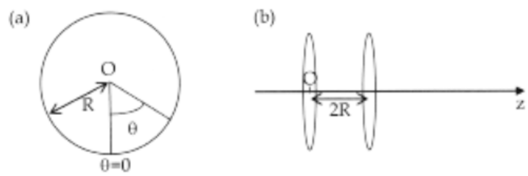

Figure 1: Setup for problem 2.1

2.2 Fields from Rings

A flat ring of inner radius R_1 and outer radius R_2 carries a non-uniform surface charge density $\sigma(r)= \frac{\beta}{r}$, where β is a positive constant, and r is the radial distance measured form the center of the ring. Calculate the electric field produced by such a charge distribution at any point on the symmetry axis.

(*Source: Bordel Spring 2014 Midterm 2*)

2.3 Dipoles with Lines

Figure **??** shows two equal and opposite charges, q, separated by a fixed distance, d. The rod connecting the two charges is at an angle, θ, from the horizontal axis, and at a distance $r >> d$, form an infinite line of charge with charge per unit length, $\lambda > 0$. ***This line of charge points out of the page.*** Find the force $\vec{F}$, on the charges to the lowest, nontrivial order in d/r when $\theta = 0$ and when $\theta = 90^o$. Express them in terms of any of the variables given and ϵ_0.

(*Source: Speliotopoulos Spring 2014 Midterm 2*)

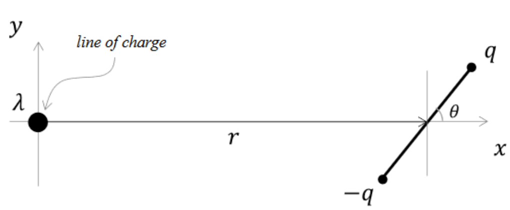

Figure 2: Setup for problem 2.3