

Week 7, Session 2 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 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)

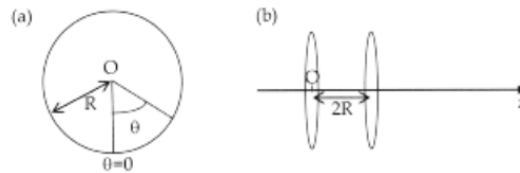


Figure 1: Setup for problem 2.1

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 from 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 $r \gg d$, from 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 $\theta = 90^\circ$. Express them in terms of any of the variables given and ϵ_0 .

(Source: Speliotopoulos Spring 2014 Midterm 2)

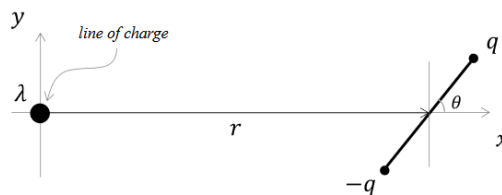


Figure 2: Setup for problem 2.3