Group #	Student	Last Name	First Name
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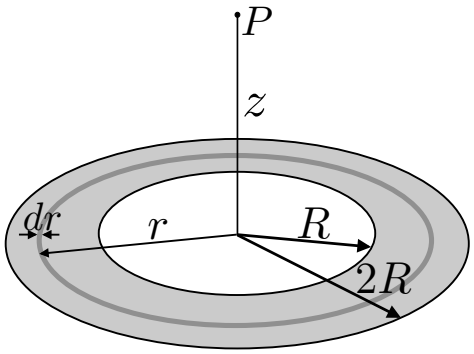
(10 marks) Find the electric field at a point P, located a distance z above the centre of a positively charged washer. The washer has an inner radius R, an outer radius $2R$, and a surface charge density σ. Hint: consider the electric field due to a ring of charge of radius r: $\vec{E}_{ring} = \frac{1}{4\pi\epsilon_\circ}\frac{qz}{(z^2+r^2)^{3/2}}\hat{k}$



The parts below walk you through related questions, and the steps with which to solve this problem. Please show all work in the boxes provided and then choose the correct answer at the bottom

1. **(1 mark)** Briefly explain the approach you would take to calculate the electric field due to a charged washer based on the electric field due to a charged ring.

Answer: The washer can be considered as a series of concentric rings having different radii. We need to use the superposition principle to add up the electric field contributions from an infinite number of rings having infinitesimal thickness. This corresponds to integrating the infinitesimal electric field contributions over the range of radii between the inner and outer radii of the washer.

2. **(1 mark)** Find dE_z in terms of z, $\epsilon_\circ$, r and dq.

Answer:

$$E = \frac{1}{4\pi\epsilon_\circ}\frac{qz}{(z^2+r^2)^{3/2}} \quad \rightarrow \quad dE = \frac{1}{4\pi\epsilon_\circ}\frac{zdq}{(z^2+r^2)^{3/2}}$$

3. **(2 marks)** Find the surface area element, dA, in terms of r and dr.

Answer:

Circle: $A = \pi r^2 \quad \rightarrow \quad dA = 2\pi r dr$

4. **(2 marks)** Write dq in terms of of σ, r and dr.

Answer:

$q = \sigma A \quad \rightarrow \quad dq = \sigma dA \quad \rightarrow \quad dq = 2\pi r \sigma dr$

5. **(3 marks)** Rewrite dE_z in terms of z, $\epsilon_\circ$, r and dr, and state the bounds of integration for r needed to calculate $\vec{E}$.

Answer:

$$dE_z = \frac{1}{4\pi\epsilon_\circ}\frac{z(2\pi r\sigma)dr}{(z^2+r^2)^{3/2}} \quad \rightarrow \quad dE_z = \frac{\sigma z}{2\epsilon_\circ}\frac{r}{(z^2+r^2)^{3/2}}dr \qquad R \leq r \leq 2R$$

(1 mark for the correct answer) Choose the correct integral describing the electric field at point P due to the charged washer.

A. $\vec{E} = \frac{\sigma z}{2\epsilon_\circ}\int_R^{2R}\frac{r}{(z^2+r^2)^{3/2}}dr\hat{r}$ B. $\vec{E} = \frac{\sigma z}{2\epsilon_\circ}\int_R^{2R}\frac{r}{(z^2+r^2)^{3/2}}dr\hat{k}$

C. $\vec{E} = \frac{\sigma z}{2\epsilon_\circ}\int_0^{R}\frac{r}{(z^2+r^2)^{3/2}}dr\hat{k}$ D. $\vec{E} = \frac{\sigma r}{2\epsilon_\circ}\int_R^{2R}\frac{z}{(z^2+r^2)^{3/2}}dz\hat{k}$