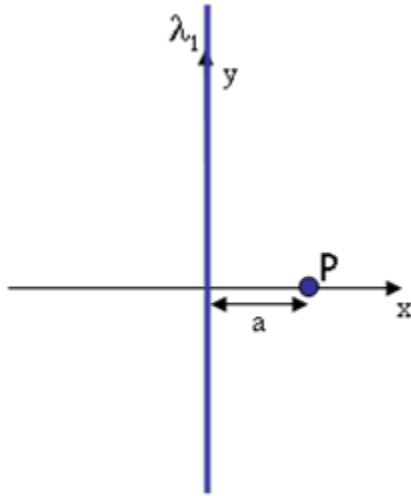


Electric Flux and Field from Lines of Charge



An infinite line of charge with charge density $\lambda_1 = -2.3 \text{ } \mu\text{C}/\text{cm}$ is aligned with the y-axis as shown.

1)

What is $E_x(P)$, the value of the x-component of the electric field produced by the line of charge at point P which is located at $(x,y) = (a,0)$, where $a = 9.3 \text{ cm}$?

N/C

We make use of Gauss' law to find the electric field equation. Remember E-field is only going out in the radial direction because it's coming from an infinite line of charge. Thus when we consider the area the E field goes through we make a Gaussian cylinder but only worry about the area of the sides and not the ends.

$$\int \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{\text{Enclosed}}}{\epsilon_0}$$

$$E2\pi rL = \frac{\lambda L}{\epsilon_0}$$

$$E = \frac{\lambda}{2\pi r\epsilon_0}$$

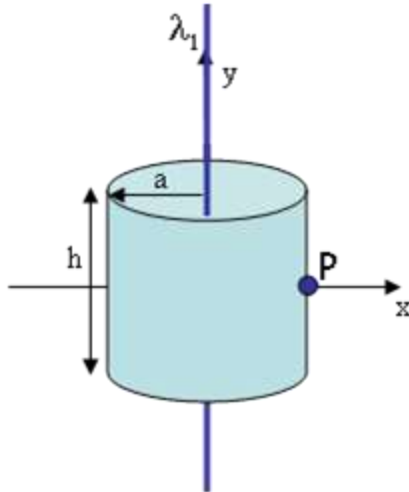
2)

What is $E_y(P)$, the value of the y-component of the electric field produced by the line of charge at point P which is located at $(x,y) = (a,0)$, where $a = 9.3 \text{ cm}$?

N/C

Because it's an infinite line of charge, the E field goes in the radial direction and nothing is in the Y.

3)



A cylinder of radius $a = 9.3$ cm and height $h = 10.4$ cm is aligned with its axis along the y -axis as shown. What is the total flux Φ that passes through the cylindrical surface? Enter a positive number if the net flux leaves the cylinder and a negative number if the net flux enters the cylinder.

N·m²/C

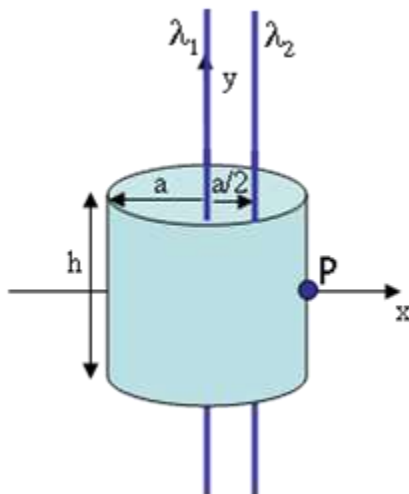
Using Gauss' law we know that:

$$\int \mathbf{E} \cdot d\mathbf{A} = \varphi = \frac{Q_{\text{Enclosed}}}{\epsilon_0}$$

So we only have to worry about the charge enclosed in our Gaussian cylinder:

$$\varphi = \frac{\lambda L}{\epsilon_0}$$

4)



Another infinite line of charge with charge density $\lambda_2 = 6.9$ $\mu\text{C}/\text{cm}$ parallel to the y -axis is now added at $x = 4.65$ cm as shown.

What is the new value for $E_x(P)$, the x-component of the electric field at point P?

N/C

We can just use superposition and add the electric fields from the two lines of charge. To find the field of the second line of charge we just use the equation

$$E = \frac{\lambda}{2\pi r \epsilon_0}$$

Keeping in mind however the distance r will be shorter, i.e. $9.3 - 4.65 = 4.65$ cm in my case

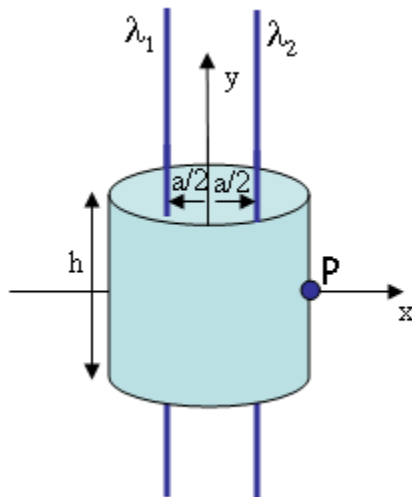
5)

What is the total flux Φ that now passes through the cylindrical surface? Enter a positive number if the net flux leaves the cylinder and a negative number if the net flux enters the cylinder.

N·m²/C

Since the total charge enclosed in our cylinder has not changed, the total flux has not changed from problem (3).

6)



The initial infinite line of charge is now moved so that it is parallel to the y-axis at $x = -4.65$ cm.

What is the new value for $E_x(P)$, the x-component of the electric field at point P?

N/C

This is exactly like problem 4 except the first line of charge is at a new distance now, of $r = 9.3 + 4.65 = 13.95$ cm.

7)

What is the total flux Φ that now passes through the cylindrical surface? Enter a positive number if the net flux leaves the cylinder and a negative number if the net flux enters the cylinder.

N·m²/C

Doesn't change. Same reasoning as in problem (5).

$$\int \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{Enclosed}}{\epsilon_0}$$

$$E2\pi rL = \frac{\lambda L}{\epsilon_0}$$

$$E = \frac{\lambda}{2\pi r\epsilon_0}$$