Physics C Unit 8 FRQs

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1.

a.

i.

$$
\begin{aligned}
E_A &= \int dE_A \\
&= \int \frac{kdq}{r^2} \\
&= k\int_0^L \frac{dq}{(a+x)^2} \\
&= k\int_0^L \frac{\lambda_0 dx}{(a+x)^2} \\
&= k\lambda_0 \left(\frac{1}{a+x}\Big|_0^L \right) \\
&= k\lambda_0 \left(\frac{1}{a+L} - \frac{1}{a} \right)
\end{aligned}
$$

ii.

$$
\begin{aligned}
E_B &= \int dE_B \\
&= \int \frac{kdq}{r^2} \cdot \frac{a}{r} \\
&= k\int \frac{a\lambda_0}{(a^2+x^2)^{3/2}} dx \\
&= k\lambda_0 a \int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{1}{(a^2+x^2)^{3/2}} dx
\end{aligned}
$$

iii. The magnitude $E_{new} > E_A$ because everything is the same except more charge is concentrated closer to the point A, meaning that the electric field is stronger at point A.

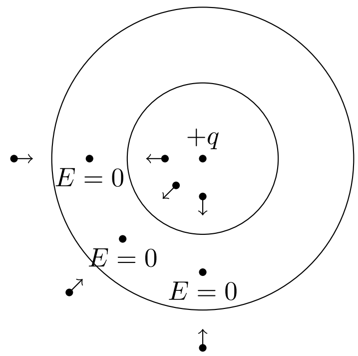
b.

Using a Gaussian surface of a cylinder of radius a and length l:

$$
\begin{aligned}
E_B \cdot A &= \frac{Q_{enc}}{\varepsilon_0} \\
E_B \cdot 2\pi a l &= \frac{\lambda_0 l}{\varepsilon_0} \\
E_B &= \frac{\lambda_0}{2\pi a \varepsilon_0}
\end{aligned}
$$

2.

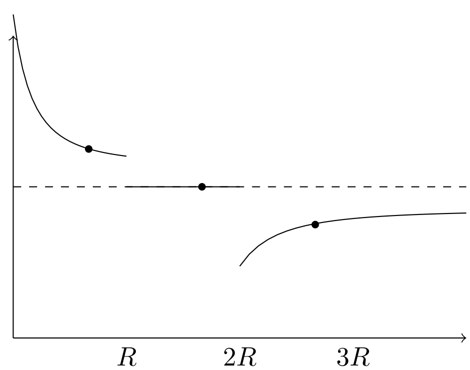
a.



b.

Inside the smaller shell @ $r = \frac{2}{3}R$: $Q_{enc} = q$ and $EA = E_0 \cdot 4\pi \left(\frac{2R}{3}\right)^2$
The inner shell must have charge of $-q$ to result in a field of zero.
The net charge @ $r = \frac{8}{3}$: $EA = -E_0 \cdot 4\pi \left(\frac{8R}{3}\right)^2$
Thus, the outer shell must have a charge of $-16q$ to result in a field of -E_0.

c.



d.

The only part that would change would be $r > 2R$, and there would be no electric field at this point because the enclosed charge would be zero.

4.

a.

Electric field from Sphere 2 is only in the $-y$ direction, and electric field from Sphere 1 is both in $-x$ and $-y$ directions, with a larger $-y$ direction. This means that net electric field is mostly in the $-y$ direction, with a slight skew towards the $-x$ direction.

b.

F_q is only in the -y direction, so we can use the $-y$ component of the electric field to find the force on the charge.

$$\begin{aligned} F_q &= 2 \cdot k\frac{Qq}{r^2} \cdot \frac{y}{r} \\ &= 2 \cdot k\frac{Qq}{\frac{D^2}{4} + y^2} \cdot \frac{y}{\sqrt{\frac{D^2}{4} + y^2}} \\ &= \frac{2kQqy}{\left(\frac{D^2}{4} + y^2\right)^{3/2}} \end{aligned}$$

c.

This time F_y would be zero because the two fields cancel out, and F_x would be double the force from one sphere. Overall, the magnitude would be multiplied by $\dfrac{D}{2y}$