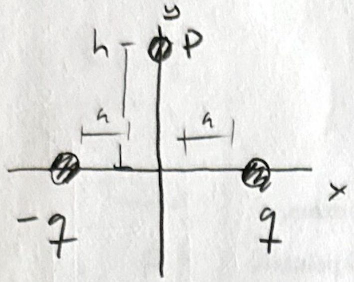
1.



Problem 1-Exam 1

$q = q \rightarrow \quad q - q = 0$

a) The y-components will be 0, and the add vectorally due to symmetry, so the field will point in the negative x-direction. $\boxed{-\hat{i}}$

$\longleftarrow$ (0,0)

b) $\vec{E}_{+q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(a^2+h^2)^{3/2}}(-a\hat{i} + h\hat{j})$ Coulombs Law

$\vec{E}_{-q} = \frac{1}{4\pi\varepsilon_0}\frac{-q}{(a^2+h^2)^{3/2}}(a\hat{i} + h\hat{j})$

$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(a^2+h^2)^{3/2}}(-a\hat{i} + \cancel{h\hat{j}}) + \frac{1}{4\pi\varepsilon_0}\frac{q}{(a^2+h^2)^{3/2}}(-a\hat{i} - \cancel{h\hat{j}})$

$\vec{E}_{tot} = \sum_{0} E_i$

$$\boxed{\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{(a^2+h^2)^{3/2}}(-2a\hat{i})}$$

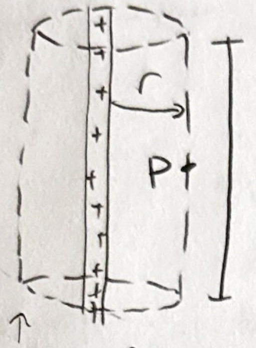
(No c)

d) $\vec{F} = Q\vec{E}$

$\vec{F} = (-Q)\left(\frac{-2aq\hat{i}}{4\pi\varepsilon_0}\cdot\frac{1}{(a^2+h^2)^{3/2}}\right)$

$$\boxed{\vec{F} = \frac{2aqQ\,\hat{i}}{4\pi\varepsilon_0(a^2+h^2)^{3/2}}}$$

2. $\lambda = \frac{Q}{L}$



Gaussian Surface in (a)

Simple geometry - no vertical components/ contribution

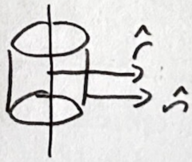
a) I will use a cylinder with length l, as it will allow me to find the enclosed charge easily with λl, while also allowing me to cancel l in the final answer as l will appear in the cylinders area and Q_{enc}. This is important so that $\vec{E}$ does not depend on any parameters of the surface (l in this case).

b) It will point radially outward at P, as The line is positively charged and thus the field is in the $\hat{r}$ direction. $\boxed{\hat{r}}$

c) $Q_{enc} = \left\{\frac{\text{charge}}{\text{length}}\right\} \cdot \{\text{length}\} = \lambda \cdot l$ $\boxed{Q_{enc} = \lambda l}$

d) $\Phi_E = \oint \vec{E} d\vec{a} = E\int da = Ea = E(2\pi r l)$

- $\hat{n}$ in $\hat{r}$ direction, so $\theta = 0$: $\cos\theta = 1$
- $\vec{E}$ doesn't depend on area by choice of Gaussian surface



$\boxed{\Phi_E = E 2\pi r l}$

e) $\frac{Q_{enc}}{\varepsilon_0} = \Phi_E = E(2\pi r l)$ $\{Q_{enc} = \lambda \cdot l\}$ from (c)

(Gauss law)

$\frac{\lambda l}{\varepsilon_0} = E(2\pi r l) \Rightarrow \boxed{\vec{E} = \frac{\lambda}{2\pi r \varepsilon_0}\hat{r}}$

in $\hat{r}$ due to b's answer