Workshop 2.2 Solutions

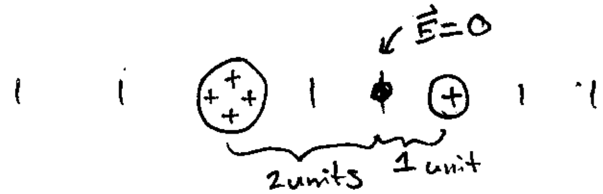
Conceptual

27.2 Find where $\vec{E} = 0$

a) The point must be between 2 charges since $\vec{E}$ vectors point in <u>same</u> direction outside the charges (cannot cancel)

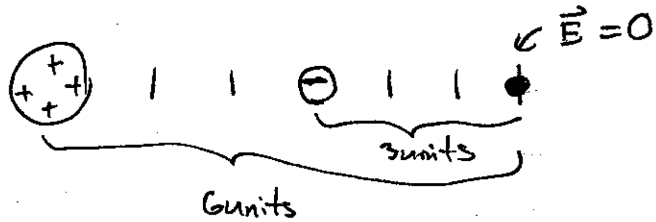
Compute where magnitudes are equal $\frac{|\vec{E}_{4+}|}{|\vec{E}_{1+}|} = \frac{k(4e)/r_{4+}^2}{k(1e)/r_{1+}^2} = 1$

$$\Rightarrow \frac{r_{1+}^2}{r_{4+}^2} = \frac{1}{4} \Rightarrow \frac{r_{1+}}{r_{4+}} = \frac{1}{2}$$



b) Now point must be <u>outside</u> charges since $\vec{E}$ vectors point in <u>same</u> direction <u>inside</u>.

The magnitude calculation is the same: $\frac{r_{1-}}{r_{4+}} = \frac{1}{2} \left(= \frac{3}{6}\right)$



27.3 $E_3 = E_4 > E_2 > E_1$ the magnitude of the electric field is proportional to the <u>density</u> of field lines.

27.12 $E_1 = E_2 = E_3 = E_4 = E_5$

all $\vec{E}$ vectors are same length (and same direction)

→ this is the usual case for parallel uniformly charged plates

27.13 for a parallel plate capacitor, $|E| = \frac{\eta}{\varepsilon_0}$ where η is the charge per unit area on the plate: $\eta = \frac{Q}{\text{area}} = \frac{Q}{L^2}$

a) $E_0 = \frac{Q}{\varepsilon_0 L^2}$ (initial field)

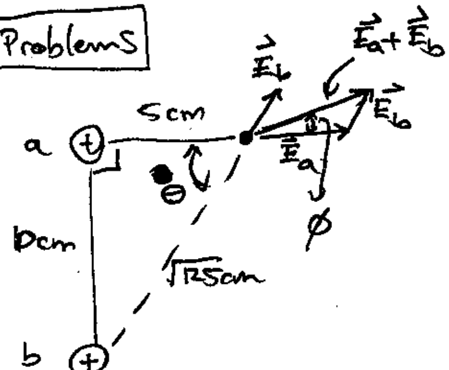
if Q is doubled, $E_f = \frac{2Q}{\varepsilon_0 L^2} = 2E_0$ (electric field is doubled)

b) L is doubled $E_f = \frac{Q}{\varepsilon_0 (2L)^2} = \frac{Q}{4\varepsilon_0 L^2} = \frac{E_0}{4}$ (electric field is quartered)

c) d is doubled: E is independent of d (electric field is the same)

(this assumes negligible fringe effects)

27.2 Problems



$$\vec{E}_a = \frac{K(3\times10^{-9}C)}{(.05m)^2}\,\hat{i}$$

$$\vec{E}_b = \frac{K(3\times10^{-9}C)}{(.05m)^2 + (.1m)^2}\left[\cos\theta\,\hat{i} + \sin\theta\,\hat{j}\right]$$

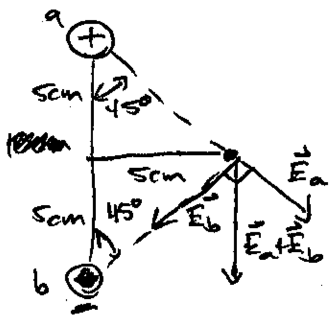
$$= \frac{K(3\times10^{-9}C)}{(.05m)^2 + (.1m)^2}\left[\frac{5}{\sqrt{125}}\,\hat{i} + \frac{10}{\sqrt{125}}\,\hat{j}\right]$$

$$\boxed{\vec{E}_a + \vec{E}_b = 1.2\times10^4\,N/C\,\hat{i} + .19\times10^4\,N/C\,\hat{j}}$$

$$\boxed{|\vec{E}_{tot}| = 1.2\times10^4\,N/C}$$

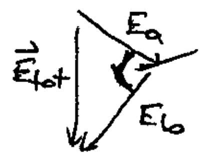
$$\boxed{\phi = \tan^{-1}\left(\frac{.19\times10^4\,N/C}{1.2\times10^4\,N/C}\right) = 9^\circ \text{ above horizontal}}$$

27.4 Problems



Note that $\hat{i}$ component cancels

→ draw vectors tip to tail:



angle is 90° ⇒ $|E_{tot}| = \sqrt{|E_a|^2 + |E_b|^2}$

and $|E_a| = |E_b|$

$$|\vec{E}_{tot}| = \sqrt{2}\,|\vec{E}_a| = \frac{\sqrt{2}\ K(3\times10^{-9}\,C)}{(.05m)^2+(.05m)^2} = 7.6\times10^{3}\ N/C$$

$$\boxed{\vec{E}_{tot} = 7.6\times10^{3}\ N/C\ (-\hat{j})}$$