Minggu 3 : Medan listrik (E) & medan magnet (B)

↓ muatan diam ↓ muatan bergerak → kawat berarus

2. Besar medan listrik yang dipengaruhi oleh n-buah titik muatan adalah sebagai berikut:

$$\mathbf{E}(\mathbf{r}) = \sum_{m=1}^{n} \frac{Q_m}{4\pi\epsilon_0 |\mathbf{r} - \mathbf{r}_m|^2} \hat{\mathbf{a}}_m \quad \text{(vektor)} \longrightarrow E = k\frac{Q}{r^2}$$

$k = 9 \times 10^9 \ Nm^2/C^2$, $Q \to C$, $r \to m$

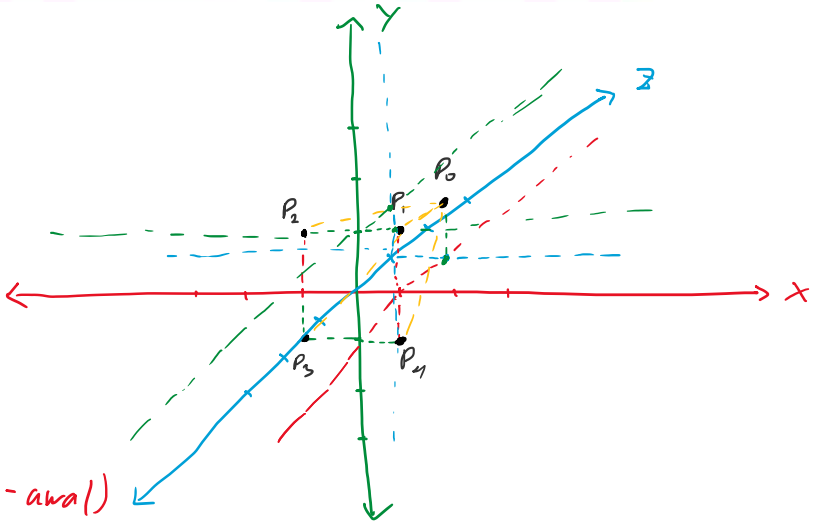
Diketahui terdapat 4 muatan identik sebesar 3-nC (nano Coloumb) yang terletak dititik P1(1,1,0), P2(-1,1,0), P3(-1,-1,0), P4(1,-1,0). Ke empat titik muatan tersebut menghasilkan suatu medan listrik E_{P0} di titik P0 (1,1,1).

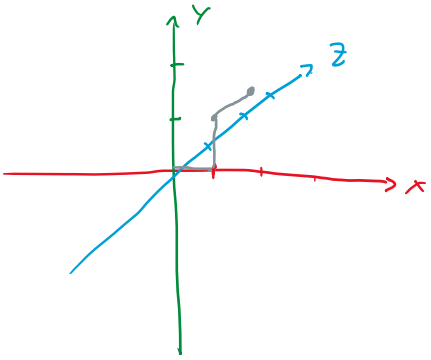
a. Gambarkan vector ke-empat titik muatan terhadap titik P0 tersebut dalam koordinat kartesian.

b. Tentukan besarnya medan listrik E_{P0} yang dipengaruhi oleh ke-empat titik muatan tersebut

$q = 3nC = 3 \times 10^{-9}$

a.





(tujuan - awal)

$\vec{r}_{10} = (1,1,1) - (1,1,0) = (0,0,1) = 0\hat{i} + 0\hat{j} + 1\hat{k} = \hat{k}$

$\vec{r}_{20} = (1,1,1) - (-1,1,0) = (2,0,1) = 2\hat{i} + 0\hat{j} + 1\hat{k} = 2\hat{i} + \hat{k}$

$\vec{r}_{30} = (1,1,1) - (-1,-1,0) = (2,2,1) = 2\hat{i} + 2\hat{j} + \hat{k}$

$\vec{r}_{40} = (1,1,1) - (1,-1,0) = (0,2,1) = 2\hat{j} + \hat{k}$

$\vec{r} = r_x\hat{i} + r_y\hat{j} + r_z\hat{k}$

$|\vec{r}| = \sqrt{r_x^2 + r_y^2 + r_z^2}$

b.

$$\vec{E} = k\frac{q}{|\vec{r}|^2} \cdot \frac{\vec{r}}{|\vec{r}|}$$

$$\vec{E}_{10} = k\frac{q}{|\vec{r}_{10}|^2} \cdot \frac{\vec{r}_{10}}{|\vec{r}_{10}|} = k\frac{q}{0^2+0^2+1^2} \cdot \frac{\hat{k}}{\sqrt{0^2+0^2+1^2}} = kq\hat{k}$$

$$\vec{E}_{20} = k\frac{q}{|\vec{r}_{20}|^2} \cdot \frac{\vec{r}_{20}}{|\vec{r}_{20}|} = k\frac{q}{2^2+0^2+1^2} \cdot \frac{2\hat{i}+\hat{k}}{\sqrt{2^2+0^2+1^2}} = \frac{kq}{5}\left(\frac{2\hat{i}+\hat{k}}{\sqrt{5}}\right)$$

$$\vec{E}_{30} = k\frac{q}{|\vec{r}_{30}|^2} \cdot \frac{\vec{r}_{30}}{|\vec{r}_{30}|} = k\frac{q}{2^2+2^2+1^2} \cdot \frac{2\hat{i}+2\hat{j}+\hat{k}}{\sqrt{2^2+2^2+1^2}} = \frac{kq}{9}\left(\frac{2\hat{i}+2\hat{j}+\hat{k}}{3}\right)$$

$$\vec{E}_{40} = k\frac{q}{|\vec{r}_{40}|^2} \cdot \frac{\vec{r}_{40}}{|\vec{r}_{40}|} = k\frac{q}{0^2+2^2+1^2} \cdot \frac{2\hat{j}+\hat{k}}{\sqrt{0^2+2^2+1^2}} = \frac{kq}{5}\left(\frac{2\hat{j}+\hat{k}}{\sqrt{5}}\right)$$

$$\vec{E}_{P0} = \vec{E}_{10} + \vec{E}_{20} + \vec{E}_{30} + \vec{E}_{40} = kq\hat{k} + \frac{kq}{5}\left(\frac{2\hat{i}+\hat{k}}{\sqrt{5}}\right) + \frac{kq}{9}\left(\frac{2\hat{i}+2\hat{j}+\hat{k}}{3}\right) + \frac{kq}{5}\left(\frac{2\hat{j}+\hat{k}}{\sqrt{5}}\right)$$

$$\vec{E}_{P0} = kq\left(\left(\frac{2\hat{i}}{9\sqrt{5}} + \frac{2\hat{i}}{27}\right) + \left(\frac{2\hat{j}}{27} + \frac{2\hat{j}}{5\sqrt{5}}\right) + \left(\hat{k} + \frac{\hat{k}}{9\sqrt{5}} + \frac{\hat{k}}{27} + \frac{\hat{k}}{9\sqrt{5}}\right)\right) = 27\left(0{,}253\hat{i} + 0{,}253\hat{j} + 1{,}216\hat{k}\right) N/C$$