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Ayo berlatih. (General Motion of a particle in three dimention)

(4.1) a) $V = Cxyz + c$

$\Rightarrow \vec{F} = -\vec{\nabla}V = -\hat{i}\frac{\partial V}{\partial x} - \hat{j}\frac{\partial V}{\partial y} - \hat{k}\frac{\partial V}{\partial z} = -c(\hat{i}yz + \hat{j}xz + \hat{k}xy)$

b) $V = \alpha x^2 + \beta y^2 + \gamma z^2 + c$

$\Rightarrow \vec{F} - \vec{\nabla}V = -\hat{i}2\alpha + \hat{j}2\beta y + \hat{k}2 . \gamma z$

c) $V = Ce^{-(\alpha x + \beta y + \gamma z)}$

$\Rightarrow \vec{F} = -\vec{\nabla}V = Ce^{-(\alpha x + \beta y + \gamma z)}(\hat{i}\alpha + \hat{j}\beta + \hat{k}\gamma)$

d) $V = Cr^n$ dalam koordinat bola

$\Rightarrow \vec{F} = -\vec{\nabla}V = -\hat{e}_r\frac{\partial V}{\partial r} - \hat{e} . \frac{1}{r}\frac{\partial V}{\partial \theta} - \hat{e} . \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}$

(4.2) a) $\vec{F} = \hat{i}x + \hat{j}y + \hat{k}z$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix} = 0 \rightarrow \text{konservatif}$$

b) $\vec{F} = \hat{i}x - \hat{j}y + \hat{k}z^2$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & -y & z^2 \end{vmatrix} = \hat{k}(-1-1) \neq 0$$

$\hookrightarrow$ tidak konservatif

c) $F = \hat{i}x + \hat{j}y + \hat{k}z^2$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z^2 \end{vmatrix} = \hat{k}\,(1-1) = 0 \rightarrow \text{konservatif}$$

d) $F = -kr^{-n}\, e_r$ dalam koordinat bola

Jawab :

$$\vec{\nabla} \times \vec{F} = \frac{1}{r^2 \sin\theta} \begin{vmatrix} \hat{e}_r & \hat{e}_{\theta} r & \hat{e}_{\phi} r \sin\theta \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \phi} \\ -kr & 0 & 0 \end{vmatrix} = 0$$

(konservatif)

4.2 a) $F = \hat{i}xy + \hat{j}cx^2 + \hat{k}z^2$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ xy & cx^2 & z^2 \end{vmatrix} = k\,(2(x-x))$$

$$2cx - x = 0 \rightarrow c = \frac{1}{2}$$

c) $F = i\,(z/y) + cj\,(xz/y^2) + k\,(x/y)$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{z}{y} & \frac{cxz}{y^2} & \frac{x}{y} \end{vmatrix} = \hat{i}\left(-\frac{x}{y} - \frac{cx}{y^2}\right) + \hat{j}\left(\frac{1}{y} - \frac{1}{y}\right) + \hat{k}\left(\frac{cz}{y^2} + \frac{z}{y^2}\right)$$

$$-\frac{x}{y^2} - \frac{cx}{y^2} = 0 \rightarrow c = -1$$

juga $\frac{cz}{y^2} + \frac{z}{y^2} = 0 \rightarrow c = -1$

b) $F = i(z/y) + cj(xz/y^2) + k(x/y)$

Jawab:

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ xy & cx^2 & z^2 \end{vmatrix} = k$$

4.4 a) Jawab:

E = konstan $= V(x,y,z) + \frac{1}{2}mv^2$

diasalnya, $E = 0 + \frac{1}{2}mv^2$

Pada $(1,1,1)$ $E = \alpha + \beta + y + \frac{1}{2}mv^2 = \frac{1}{2}mv^2$

b) Jawaban:

$$V_0 = \frac{2}{m}(\alpha + \beta + y) = 0$$

$$V_0 = \left[\frac{2}{m}(\alpha + \beta + y)\right]^{\frac{1}{2}}$$

c) Jawab:

$$m\ddot{x} = F_x = -\frac{\partial V}{\partial x}$$

$$m\ddot{x} = -\alpha$$

$$m\ddot{y} = -\frac{\partial V}{\partial y} = -2\beta y$$

$$mz = -\frac{\partial V}{\partial z} = 3yz^2$$

4.5 Pertimbangkan 2 fungsi gaya

a) $F = \hat{i}x + \hat{j}\dot{y}$

Jawab:

$$\vec{F} = \hat{i}x + \hat{j}y$$

di $x = y$ i $\quad \vec{dr} = \hat{i}\,dx + \hat{j}\,dy$

$$\int_{(0,0)}^{(1,1)} \vec{F}\cdot\vec{dr} = \int_0^1 F_x\,dx + \int_0^1 F_y\,dy = \int_0^1 x\,dx + \int_0^1 y\,dy = -1$$

Pada lintaran sepanjang sbx : $\vec{dr} = \hat{i}\, dx$

dan pd garis $x = 1$ $\qquad \vec{dr} = \hat{j}\, dy$

$$\int_{(0,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = \int_0^1 F_x\, dx + \int_0^1 F_y\, dy = 1, \ \vec{F} = \text{konservatif}$$

b) $\vec{F} = \hat{i} y - \hat{j} x$

di $x = y$. $\int_{(0,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = \int_0^1 F_x\, dx + \int_0^1 F_y\, dy = \int_0^1 y\, dx - \int_0^1 x\, dy$

dan dg $x = y$ $\int_{(0,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = \int_0^1 x\, dx - \int_0^1 y\, dy = 0$

Pada sumbu x : $\int_{(0,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = \int_0^1 F_x\, dx = \int_0^1 y\, dx$

dan, dg $y = 0$ pd sbx $\int_{(0,0)}^{(1,0)} \vec{F} \cdot \vec{dr} = 0$

Pada garis $x = 1$ $\int_{(1,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = \int_0^1 F_y\, dy = \int_0^1 x\, dy$

dan dg $x = 1$ $\int_{(1,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = \int_0^1 dy = 1$

Pada jalur ini $\int_{(0,0)}^{(1,1)} \vec{F} \cdot \vec{dr} = 0 + 1 = 1$, $\vec{F}$ = tidak konservatif

4.6 Jawab :

Dari contoh 2.3.2 . $V(z) = -mg \dfrac{r_e^2}{(r_e + z)}$

$$V(z) = -mg\, r_e \left(1 + \frac{z}{r_e}\right)^{-1}$$

$$V(z) = -mg\, r_e \left(1 - \frac{z}{r_e} + \frac{z^2}{r_e} + \dots\right)$$

$$V(z) = -mg\, r_e + mgz - \frac{mgz}{r_e} + \dots$$

dg $-mg\, r_e$ sebuah konstan

$$V(z) \approx mgz \left(1 - \frac{z}{r_e}\right)$$

$$\vec{F} = -\vec{\nabla} V = -\hat{k} \frac{\partial}{\partial z} V(z)$$

$$= -\hat{k} mg \left[1 - \frac{z}{r_e} + z\left(-\frac{1}{r_e}\right)\right]$$

$$\vec{F} = -\hat{k} mg \left(1 - \frac{2z}{r_e}\right)$$

$$m\ddot{x} = F_x = 0$$

$$m\ddot{z}\,\frac{dz}{dz} = -mg\left(1 - \frac{2z}{r_e}\right)$$

$$\int_{V_z}^{0} \dot{z}\,dz = -g \cdot \int_0^{m} \left(1 - \frac{2z}{r_e}\right) dz$$

$$-\frac{1}{2} V_{0z}^2 = -g\left(h - \frac{h^2}{r_e}\right)$$

$$h^2 - r_e h + \frac{r_e V_{0z}^2}{2g} = 0$$

$$h - r_e h + \frac{r_e V_{0z}^2}{2g} = 0$$

$$h = \frac{r_e}{2} - \frac{1}{2}\sqrt{r_e^2 - \frac{2 r_e V_{0z}^2}{g r_e}} \quad (hz << r_e)$$

$$h = \frac{r_e}{2} - \frac{r_e}{2}\sqrt{1 - \frac{2V_{0z}^2}{g r_e}}$$

$$(1+x)^{\frac{1}{2}} = 1 + \frac{x}{2} - \frac{x^2}{2} + \ldots$$

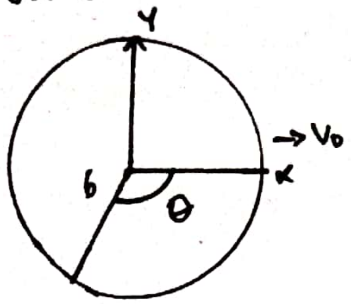
$$h = \frac{r_e}{2} - \frac{r_e}{2} + \frac{V_{0z}^2}{2g} + \frac{V_{0z}^4}{4 g r_e} + \ldots$$

$$h \approx \frac{V_{0z}^2}{2g}\left(1 + \frac{V_{0z}^2}{2 g r_e}\right)$$

dari contoh 2.3.2 $h = \frac{V_0^2}{2g}\left(1 - \frac{V_0^2}{2 g r_e}\right)^{-1}$

dan dg $(1-x)^{-1} \approx 1 + \alpha$, $h \approx \frac{V_0^2}{2g}\left(1 + \frac{V_0^2}{2 g r_e}\right)$

4.7 Jawab :



$\vec{r} : \hat{i}\, b \cos\theta - \hat{j}\, b \sin\theta$

$\theta : \omega t = \frac{V_0 t}{b}$. Jadi, $\vec{r} \cdot -\hat{i}\, V_0 \sin\theta - \hat{j}\, V_0 \cos\theta$

relatif ke kanan, $\vec{v} , \hat{i}\, V_0 (1 - \sin\theta) - \hat{j}\, V_0 \cos\theta$

Partikel keluar tepi : $y_0 : -b \sin\theta$ dan $V_{0y} : -V_0 \cos\theta$

Jadi, $V_y : V_{0y} - gt = -V_0 \cos\theta - gt$ dan $y : -b \sin\theta - V_0 t \cos\theta - \frac{1}{2} g t^2$

tinggi maks $V_y : 0$

$t = -\frac{V_0 \cos\theta}{g}$

$h = -b \sin\theta - V_0 \left(-\frac{V_0 \cos\theta}{g} \right) \cos\theta - \frac{1}{2} g \left(\frac{-V_0 \cos\theta}{g} \right)^2$

$h = -b \sin\theta = \frac{V_0^2 \cos^2\theta}{2g}$

h maks terjadi untuk $\frac{dh}{d\theta} \cdot 0 : -b \cos\theta - \frac{2 V_0^2 \cos\theta \sin\theta}{2g}$

$\sin\theta : -\frac{gb}{V_0^2}$

$\cos^2\theta : 1 - \sin^2\theta = \frac{V_0^4 - g^2 b^2}{V_0^4}$

$h_{max} : \frac{gb^2}{V_0^2} + \frac{V_0^4 g^2 b^2}{2g V_0^2} = \frac{gb^2}{2V_0^2} + \frac{V_0^2}{2g}$

Lumpur meninggalkan roda di $\theta = \sin^{-1}\left(-\frac{gb}{V_0^2} \right)$

(4.8) Jawab:

$x = R\cos\phi$ dan $x = V_0 x t = (V_0 \cos\alpha)t$

Jadi, $t = \dfrac{R\cos\phi}{V\cos\alpha}$

$y = R\sin\phi$ dan $y = V_{0y} t - \frac{1}{2}gt^2 = (V_0 \sin\alpha)t - \frac{1}{2}gt^2$

$$R\sin\theta = (V_0\sin\alpha)\frac{R\cos\phi}{V_0\cos\alpha} - \frac{1}{2}g\left(\frac{R\cos\phi}{V_0\cos\alpha}\right)^2$$

$$\sin\phi = \tan\alpha\cos\phi - \frac{gR\cos^2\phi}{2V_0^2\cos^2\alpha}$$

$$R = \frac{2V_0^2\cos^2\alpha}{g\cos\phi}(\tan\alpha\cos\phi - \sin\phi) = \frac{2V_0^2\cos\alpha}{g\cos^2\phi}\left(\sin\alpha\cos\phi - \cos\alpha\sin\phi\right)$$

$\sin(\theta+\phi) = \sin\theta\cos\phi + \cos\theta\sin\phi$

$$R = \frac{2V_0^2\cos\alpha}{g\cos^2\phi}\sin(\alpha-\phi)$$

R_{max} untuk $\dfrac{dR}{d\alpha} = 0 = \dfrac{2V_0^2}{g\cos^2\phi}\left[-\sin\alpha\sin(\alpha-\phi) + \cos\alpha\cos(\alpha-\phi)\right]$

$\cos(\theta+\phi) = \cos\theta\cos\phi - \sin\theta\sin\phi$ jadi $\cos(2\alpha-\phi) = 0$

$2\alpha - \phi = \frac{\pi}{2}$

$$R_{max} = \frac{2V_0^2}{g\cos\phi}\cos\left(\frac{\pi}{4}+\frac{\phi}{2}\right)\sin\left(\frac{\pi}{4}-\frac{\phi}{2}\right)$$

$$\sin\left(\frac{\pi}{4}-\frac{\phi}{2}\right) = \cos\left[\frac{\pi}{2}-\left(\frac{\pi}{4}-\frac{\phi}{2}\right)\right] = \cos\left(\frac{\pi}{4}+\frac{\phi}{2}\right)$$

$$R_{max} = \frac{2V_0^2}{g\cos^2\phi}\cos^2\left(\frac{\pi}{4}+\frac{\phi}{2}\right)$$

$$R_{max} = \frac{2V_0^2}{g\cos^2\phi}\left[\frac{1}{2}\cos\left(\frac{\pi}{2}+\phi\right)+\frac{1}{2}\right] = \frac{V_0^2}{g\cos^2\phi}\left[\cos\left(\frac{\pi}{2}+\phi\right)+1\right]$$

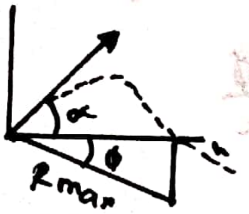
menggunakan $\cos\left(\frac{\pi}{2}+\phi\right) = -\sin\theta$

$$R_{max} = \frac{V_0^2}{g(1-\sin\phi} (1-\sin\phi)$$

$$= \frac{V_0^2}{g(1+\sin\phi)}$$

(4.9) Jawab:

a)



$$R = \frac{2V_0^2}{g} \frac{\cos\alpha \sin(\alpha+\phi)}{\cos^2\phi}$$

$-\varphi = \ldots\ R_{max} : V_0^2(1+\sin\varphi)$ dan.... $2\alpha = \frac{\pi}{2} = \beta$

$$R_{max} = \frac{h}{\sin\varphi} : \frac{V_0^2}{g} \frac{(1+\sin\beta)}{\cos^2\varphi} = \frac{V_0^2}{g(\sin\varphi)}$$

$$\sin\varphi = \frac{gh}{V_0^2} \Big/ \left(1+\frac{gh}{V_0^2}\right)$$

$$\sin\varphi = \sin\left(\frac{\pi}{2}-2\alpha\right) = \cos 2\alpha = 1-2\sin^2\alpha$$

$$1-2\sin^2\alpha = \frac{gh}{V_0^2} \Big/ \left(1+\frac{gh}{V_0^2}\right)$$

$$2\sin^2\alpha = \frac{2}{ex^2\alpha} = 1-\frac{gh}{V_0^2} \Big/ \left(1+\frac{gh}{V_0^2}\right) = \frac{1}{1+\frac{gh}{V_0^2}}$$

akhirnya $= \csc^2\alpha = 2\left(1+\frac{gh}{V_0^2}\right)$

b) Jawab:

$$R_{max} = \frac{h}{\sin\varphi} = \frac{h}{1-2\sin^2\alpha} = \frac{h}{1-2/\csc^2\alpha}$$

$$R_{max} = \frac{V_0^2}{g}\left(1+\frac{gh}{V_0^2}\right)$$

Dipindai dengan CamScanner

Jawaban

4.18 a). x dan z adalah posisi bola

$x = V_0 t \cos\frac{1}{2}\theta_0$, $z = V_0 t \cos\frac{1}{2}\theta_0 \sin\theta_0 - \frac{1}{2}gt^2$

sejak $V_x = V_0 \cos\frac{1}{2}\theta_0$

$$R = \frac{V_0^2}{g}\cos^2\frac{1}{2}\theta_0 \sin 2\theta_0$$

max $\frac{dR}{d\theta} = 0$

$$\frac{dR}{d\theta} = \frac{V_0^2}{g}\left(2\cos^2\frac{1}{2}\theta_0 \cos 2\theta_0 - \cos\frac{1}{2}\theta_0 \sin\frac{1}{2}\theta \sin 2\theta_0\right) = 0$$

$2\cos^2\frac{1}{2}\theta_0 \cos^2\theta_0 = \cos\frac{1}{2}\theta_0 \sin\frac{1}{2}\theta_0 \sin\theta_0$

$2\cos^2\theta_0 = 1 + \cos 2\theta_0$ dan $\sin 2\theta = 2\sin\theta_0 \sin 2\theta_0$

didapat : $(1+\cos\theta_0)(2\cos^2\theta_0 - 1) = \sin\theta_0 \sin\theta_0 \cos\theta_0 = (1-\cos^2\theta\cos\theta)$

atau $(1+\cos\theta_0)(3\cos^2\theta_0 - \cos\theta_0 - 1) = 0$

hanya akar positif yang berlaku adalah $\theta, 0 \leq \theta \leq \frac{\pi}{2}$

$\cos\theta_0 = \frac{1}{6}(1+\sqrt{13}) = 0{,}7676$ $\quad \theta_0 = 39°51'$

b) untuk $V_0 = 25\,m/s$ $R_{max} = 55{,}4\,m$ $\quad \theta_0 = 39°51'$

max $\frac{dz}{dt} = 0$

$V_0 \cos\frac{1}{2}\theta_0 \sin\theta_0 = gt$ atau $T = \frac{V_0 \cos\frac{1}{2}\theta_0 \sin\theta_0}{g}$

atau $H = \frac{V_0^2}{2g}\cos^2\frac{1}{2}\theta_0 \sin^2\theta_0$. x tetap di θ, max pada

ketinggian tetap terjadi $\frac{dH}{d\alpha} = 0$

$$\frac{dH}{d\alpha} = \frac{V_0^2}{2g}\left(2\cos^2\frac{1}{2}\theta \cdot \sin\theta_0 \cos\theta_0 - \cos\frac{1}{2}\theta_0 \sin\frac{1}{2}\theta_0 \sin^2\theta\right) = 0$$

$$(1+\cos\theta_0)\sin\theta_0 \cos\theta_0 - \frac{1}{2}\sin\theta_0 \sin^2\theta_0 = \frac{\frac{1}{2}\sin\theta_0(1-\cos^2\theta_0)}{\sin\theta_0(1+\cos\theta_0)(3\cos\theta_0 - 1} = 0$$

$\sin\theta = 0$ $\quad \cos\theta_0 = -1$

jadi, $H_{max} = 10{,}9\,m$ $\quad \theta_0 = \cos^{-1}\frac{1}{3} = 70{,}32°$

4.11 Jawab:

r menggantikan x

$z = \frac{\dot{z}_0}{\dot{r}_0} r - \frac{g}{2\dot{r}_0^2} r^2$ dimana $\dot{r}_0 = V_0 \cos\theta_0$ $\dot{z}_0 = V_0 \sin\theta_0$

$z = r\tan\theta_0 - \frac{gr^2}{2V_0^2}\sec^2\theta$ sejak $\sec^2\theta_0 = 1 + \tan^2\theta$

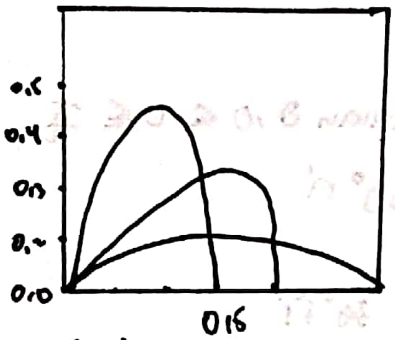
$\frac{gr^2}{2V_0^2}\tan^2\theta_0 - r\tan\theta_0 + z + \frac{gr^2}{2V_0^2} = 0$

(r, z) titik koordinat

$\tan\theta_0 = \frac{1}{gr}\left[V_0^4 \pm (V_0^4 - gzV_0^2 - g^2r^2)^{1/2}\right]$

$V_0^4 - 2gzV_0^2 - g^2r^2 \geq 0$

Permukaan kritis oleh kamaira $V_0^4 - 2gz - g^2r^2 = 0$



4.17 Jawab:

$m\ddot{x} = F_x = -\frac{\partial V}{\partial x} = -kx = -\pi^2 mx$

$\dot{x} = A = \cos\left(\sqrt{\frac{k}{m}}t + \alpha\right) = A\cos(\pi t + \alpha)$

$m\ddot{y} = -\frac{\partial V}{\partial y} = 4\pi^2 mx$

$y = B\cos(2\pi t + \beta)$

$m\ddot{z} = -\frac{\partial V}{\partial z} = -g\pi^2 mz$

$z = \cos(3\pi t + \gamma)$

Sejak $x = y = z = 0$ pada $t = 0$ dan $\beta = \gamma = \frac{\pi}{2}$

$x = A\cos(\pi t - \frac{\pi}{2}) = A\sin\pi t$

$\dot{x}_0 = A\pi \cos \pi t$

$V_0^2 = \dot{x}_0^2 + \dot{y}_0^2 + \dot{z}_0^2$ dan $\dot{x}_0 = \dot{y}_0 = \dot{z}_0$

$$\dot{x}_0 = \frac{V_0}{\sqrt{3}} = A\pi$$

$$A = \frac{V_0}{\pi\sqrt{3}}$$

$$x = \frac{V_0}{\pi\sqrt{3}} \sin \pi t$$

$y = B \sin 2\pi t$, $\dot{y} = 2B\pi \cos 2\pi t$

$$\dot{y}_0 = \frac{V_0}{\sqrt{3}} = 2\pi$$

$$B = \frac{V_0}{2\pi\sqrt{3}}$$

$$y = \frac{V_0}{2\pi\sqrt{3}} \sin 2\pi t$$

$z = C \sin 3\pi t$

$\dot{z}_0 = \frac{V_0}{\sqrt{3}} = 3\pi t$ $\quad \dot{z} = 3C\pi \cos 3\pi t$

$$\dot{z}_0 = \frac{V_0}{\sqrt{3}} = 3C\pi$$

$$C = \frac{V_0}{3\pi\sqrt{3}}$$

$$z = \frac{V_0}{3\pi\sqrt{3}} \sin 3\pi t$$

Sejak $\omega x = \pi$, $\omega y = 2\pi$, dan $\omega z = 3\pi$, maka

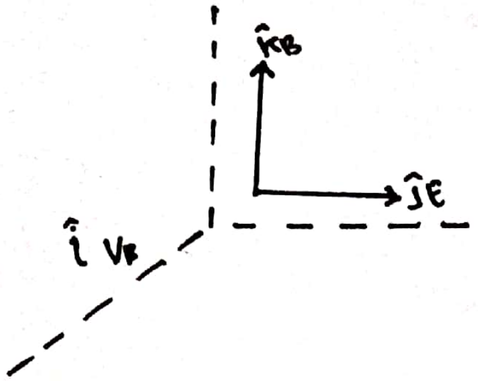
$$T_{min} = \frac{2\pi n_1}{\omega x} = \frac{2\pi n_2}{\omega y} = \frac{2\pi n_3}{\omega z}$$

waktu max pada $n_1 = 1$, $n_2 = 2$, $n_3 = 3$

$$t_{min} = \frac{2\pi}{\pi} = 2$$

Dipindai dengan CamScanner

(4.20) Jawab :



$$\vec{F} = q(\hat{E} + \vec{V} + \vec{B})$$

$$\vec{V} \times \vec{B} : (\hat{i}\dot{x} + \hat{j}\dot{y} + \hat{k}\dot{z}) \times kB : \hat{i}\dot{y}B - \hat{j}\dot{x}B$$

$$\vec{F} : \hat{i}q\dot{y}B + \hat{j}q(E - \dot{x}B)$$

$$m\ddot{x} = F_x = q\dot{y}B$$

$$\dot{x} - \dot{x}_0 : \frac{q_0}{m} = y$$

$$m\ddot{y} \cdot F_y : qE - q\dot{x}B = qE - qB\left(\dot{x}_0 + \frac{qB}{m}y\right)$$

$$\ddot{y} : \frac{qE}{m} - \frac{qB\dot{x}}{m} - \left(\frac{qB}{m}\right)^2 y = \frac{eE}{m} + \frac{EB\dot{x}}{m} - \left(\frac{eB}{m}\right)^2 y$$

$$\ddot{y} + \omega^2 y : \frac{-eE}{m} + \omega\dot{x}_0$$

$$y : \frac{1}{\omega^2}\left(-\frac{eE^m}{m} + \omega x\right) + A\cos(\omega t + \theta_0)$$

$$\dot{y} : -A\,\omega \sin(\omega t + \theta)$$

$$\dot{y}_0 : 0,\ \text{jadi } \theta_0 : 0,\quad A : -\frac{1}{\omega^2}\left(-\frac{eE}{m} + \omega\dot{x}_0\right)$$

$$y : a(1 - \cos \omega t),\ a : \frac{1}{\omega^2}\left(-\frac{eE}{m} + \omega\dot{x}_0\right)$$

$$\dot{x} : \dot{x}_0 = \frac{qB}{m}y = \dot{x} - \omega y \cdot \dot{x}_0 - \omega a(1 - \cos \omega t)$$

$$x : (\dot{x}_0 - \omega a)t + a \sin \omega t$$

$$x : a \sin \omega t + bt \qquad b : \dot{x}_0 - \omega a$$

$$m\ddot{z} : f_z : 0 \qquad z : \dot{z}_0 t + z_0 : 0$$