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Prodi : Pendidikan Fisika
Kelas : B

Ayo Berlatih (General Motion of a Particle in Three Dimensions)

(4.1) a.) $V = Cxyz + C$

Jawab :

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

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

Jawab :

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

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

Jawab :

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

d.) $V = cr^n$ dalam koordinat bola

Jawab :

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

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

Jawab :

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

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

Jawab :

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

c.) $F = \hat{i}x + \hat{j}y + \hat{k}z^3$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z^3 \end{vmatrix} = \hat{k}(1-1) = 0 \longrightarrow \text{konservatif}$$

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

Jawab :

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

(4.3) a.) $F = \hat{i}xy + \hat{j}cx^2 + \hat{k}z^3$

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ xy & cx^2 & z^3 \end{vmatrix} = k(2cx - x)$$

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

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

Jawab :

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ xy & cx^2 & z^3 \end{vmatrix} = k$$

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

Jawab :

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

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

juga $\frac{cz}{y^2} + \frac{z}{y^3} = 0 \longrightarrow c = -1$

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

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

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

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b.) Jawaban : $\dot{V_0} = \frac{2}{m} (\dot{\alpha} + \dot{\beta} + \dot{\gamma}) = \dot{0}$

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

c.) Jawaban : $m\ddot{x} = F_x = -\frac{\partial V}{\partial x}$

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

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

$$m\ddot{z} = -\frac{\partial V}{\partial z} = -3\gamma z^2$$

(4.5) Pertimbangkan 2 fungsi gaya

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

Jawab :

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

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

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

Pada lintasan sepanjang sumbu x : $d\vec{r} = \hat{i}\,dx$

dan pada garis $x = 1$ $\quad d\vec{r} = \hat{j}\,dy$

$$\int_{(0,0)}^{(1,1)} \vec{F} \cdot d\vec{r} = \int_0^1 F_x\,dx + \int_0^1 F_y\,dy = 1, \quad \vec{F} = \text{Konservatif}$$

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

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

dan, dengan $x = y$ $\quad \int_{(0,0)}^{(1,1)} \vec{F} \cdot d\vec{r} = \int_0^1 x\,dx - \int_0^1 y\,dy = 0$

pada sumbu x = $\int_{(0,0)}^{(1,1)} \vec{F} \cdot d\vec{r} = \int_0^1 F_x\,dx = \int_0^1 y\,dx$

dan, dengan $y = 0$ pada sumbu x $\quad \int_{(0,0)}^{(1,0)} \vec{F} \cdot d\vec{r} = 0$

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

dan, dengan $x = 1$ $\quad \int_{(1,0)}^{(1,1)} \vec{F} \cdot d\vec{r} = \int_0^1 dy = 1$

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pada jalur ini $\int_{(0,0)}^{(1,1)} \vec{F} \cdot d\vec{r} = 0 + 1 = 1$, $\vec{F}$ = tidak konservatif.

4.6. Jawaban :

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

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

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

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

dengan $-mg r_e$ sebuah konstan

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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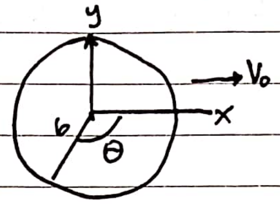
(4.7) Jawaban :



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

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

relatif ke tanah, $\vec{V} = \hat{i} V_0 (1 - \sin\theta) - \hat{j} V_0 \cos\theta$

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 maksimum $V_y = 0$

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

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

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

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

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

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

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

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

(4.8) Jawaban :

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

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

$y = R \sin\phi$ dan $y = V - yt = -\frac{1}{2} g t^2 = (V_0 \sin\alpha) t - \frac{1}{2} g t^2$

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

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

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

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

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

R_{maks}. Untuk $\frac{dR}{d\alpha} = 0 = \frac{2V_0^2}{g\cos^2\phi}\left[-\sin\alpha\sin(\alpha-\phi) + \cos\alpha\cos(\alpha-\phi)\right]$

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

$2\alpha - \phi = \frac{\pi}{2}$ $\qquad \alpha = \frac{\pi}{4} + \frac{\phi}{2}$

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

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

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

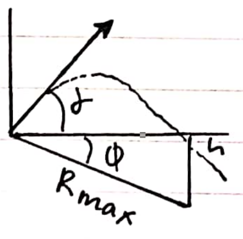
$$R_{max} = \frac{2V_0^2}{g\cos^2\phi}\left[\frac{1}{2}\cos\left(\frac{\pi}{2}+\phi\right)+\frac{1}{2}\right] = \frac{V_0^2}{g\cos^2\phi}\left[\cos\left(\frac{\pi}{2}+\phi\right)+1\right]$$

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.) a.) Jawaban :



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

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

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

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

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

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

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

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

b.) Jawaban :

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

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

4.12 a.) Jawaban

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 $V_x = V_0 \cos\frac{1}{2}\theta$,

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

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

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

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

$2\cos^2\theta_0 = 1 + \cos 2\theta_0$ 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 θ, $0 \le \theta \le \frac{\pi}{2}$

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

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

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

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

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

maks pada ketinggian tetap terjadi $\frac{dH}{d\delta} = 0$

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

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

$\sin\theta_0(1+\cos\theta_0)(3\cos\theta_0 - 1) = 0$

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

Jadi, $H_{max} = 18,9$ m $\quad\quad$ $\theta_0 = \cos^{-1}\frac{1}{3} = 70,32°$

(4.13) Jawaban :

r menggantikan x

$z = \frac{\dot z_0}{\dot r_0} r - \frac{g}{2\dot r_0^2} r^2$ dimana $\dot r_0 = V_0 \cos\theta_0$ $\quad$ $\dot z_0 = V_0 \sin\theta_0$

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

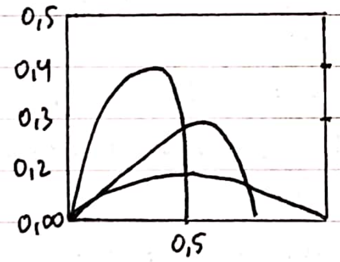
$\frac{gr^2}{2V_0^2}\tan^2\theta_0 - r\tan\theta_0 + z + \frac{gr^2}{2V_0^2} = 0$

(r, z) titik koordinat

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

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

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



(4.17) Jawaban :

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$z = C \sin 3\pi t$

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

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

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

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

Sejak $\omega_x = \pi$. $\omega_y = 2\pi$ dan $\omega_z = 3\pi$, maka

$$I_{min} = \frac{2\pi n_1}{\omega_x} = \frac{2\pi n_2}{\omega_y} = \frac{2\pi n_3}{\omega_z}$$

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

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

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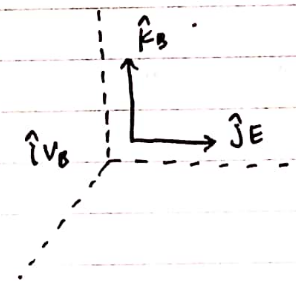
4.20 Jawaban :



$$\vec{F} = q\,(\hat{E} + \vec{v} + \vec{B})$$
$$\vec{V} \times \vec{B} = (\hat{i}\dot{x} + \hat{j}\dot{y} + \hat{k}\dot{z}) \times \hat{k}B = \hat{i}\dot{y}B - \hat{j}\dot{x}B$$
$$\vec{F} = \hat{i}q\dot{y}B + \hat{j}q\,(E - \dot{x}B)$$
$$M\ddot{x} = F_x = q\dot{y}B$$
$$\dot{x} - \dot{x}_0 = \frac{qB}{m} = y$$

$$m\ddot{y} = F_y = qE - q\dot{x}B = qE - qB\left(\dot{x}_0 + \frac{qB}{m}y\right)$$
$$\ddot{y} = \frac{qE}{m} - \frac{qB\dot{x}}{m} - \left(\frac{qB}{m}\right)^2 y = \frac{eE}{m} + \frac{EB\dot{x}}{M} - \left(\frac{eB}{m}\right)^2 y$$
$$\ddot{y} + \omega^2 y = -\frac{eE}{m} + \omega\dot{x}_0$$
$$y = \frac{1}{\omega^2}\left(-\frac{eE^m}{m} + \omega x\right) + A\cos(\omega t + \theta_0)$$
$$\dot{y} = -A\omega\sin(\omega t + \theta)$$
$$\dot{y}_0 = 0, \text{ Jadi } \theta_0 = 0,\ A = -\frac{1}{\omega^2}\left(-\frac{eE}{m} + \omega\dot{x}_0\right)$$
$$y = a(1 - \cos\omega t),\ a = \frac{1}{\omega^2}\left(-\frac{eE}{m} + \omega\dot{x}_0\right)$$
$$\dot{x} = \dot{x}_0 = \frac{qB}{m}y = \dot{x} - \omega y = \dot{x}_0 - \omega a\,(1 - \cos\omega t)$$
$$x = (\dot{x}_0 - \omega a)t + a\sin\omega t$$
$$x = a\sin\omega t + bt \qquad b = \dot{x}_0 - \omega a$$
$$M\ddot{z} = F_z = 0 \qquad z = \dot{z}_0 t + z_0 = 0$$