Solusi Lembar Tugas Mahasiswa ke-3
Fisika Dasar IA (FI-1101)

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1. A wheel of 10 cm radius rotates with a constant angular speed ω of p rad/s
   (a) If at $t = 2\,s$, a point on the edge of the wheel is at an angle $= 30°$ to the positive x-axis, determine its position at $t = 5\,s$.
   (b) Determine the magnitude of the velocity at $t = 2\,s$.
   (c) Plot the position, angular velocity, and angular acceleration as a function of time.

Materi: Benda

➢ *Gerak Melingkar Beraturan*

$$\theta_t = \theta_0 + \omega t$$

Diketahui:

$r = 10\,cm = 0.1\,m$ $\quad \theta = 30° = \frac{\pi}{6}$ $\quad \omega = p\ rad/s$ $\quad t_1 = 2\,s$ $\quad t_2 = 5\,s$

Ditanya:

$$\theta_{t=5} = \ldots \qquad \omega_{t=2} = \ldots\ rad/s$$

Jawab.

➢ a) ω konstan maka $\alpha = 0$

$$\begin{aligned}\theta_t &= \theta_0 + \omega t \\ &= \frac{\pi}{6} + p(t_2 - t_1) \\ &= \frac{\pi}{6} + p(5-2) \\ &= 3p + \frac{\pi}{6}\end{aligned}$$ □

➢ b) ω konstan

kecepatan sudut saat $t = 2$

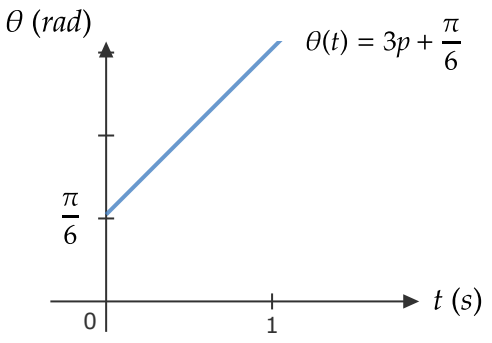
$$\begin{aligned}\omega_t &= \omega_0 \\ &= p\ \ rad/s\end{aligned}$$ □

kecepatan linier saat $t = 2$

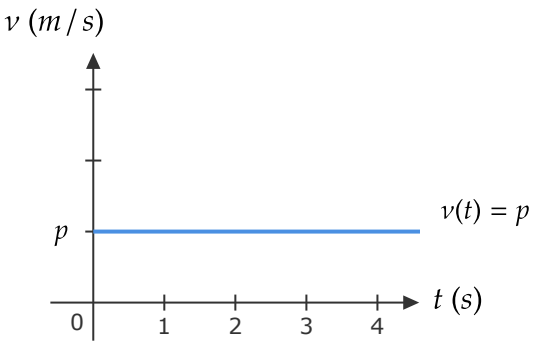
$$\begin{aligned}v &= \omega \cdot r \\ &= p\ \cdot (0.1) \\ &= 0.1p\ \ m/s\end{aligned}$$ □

➢ c)

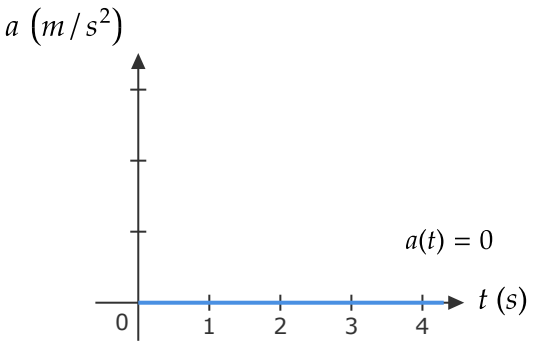
Grafik Posisi



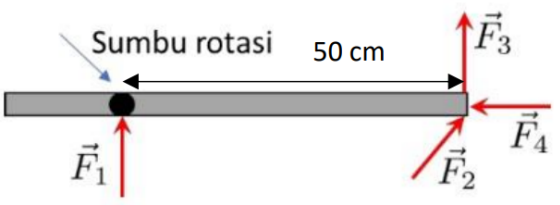
Grafik Kecepatan



Grafik Percepatan



2. In the following figure you can see a rod and its axis of rotation which is perpendicular to the image plane. If in this position four forces are applied to the rod with the magnitude of each force, $F_1 = 2\,N$, $F_2 = 5\,N$, $F_3 = 7\,N$ and $F_4 = 10\,N$, and the force F_2 forms an angle of $60°$ with the rod:
   (a) Calculate the torque exerted by each force.
   (b) If the mass of the rod is $2\,kg$ (evenly distributed) and the distance from the axis of rotation to the left end of the rod is $20\,cm$, calculate the magnitude of the rod's angular acceleration.
   (c) Calculate the rod's angular velocity when the rod forms an angle of $30°$ to its initial position.



Materi: Benda

➢ *Torsi*

$$\tau = F \times r \cdot \sin\theta$$

Diketahui:

$$F_1 = 2\,N \qquad F_2 = 5\,N \qquad F_3 = 7\,N \qquad F_4 = 10\,N \qquad \theta_{F_2} = 60°$$

Ditanya:

$$\Sigma\,\tau = \ldots\,Nm \qquad \alpha = \ldots\,rad/s^2 \qquad \omega_{\theta=30°} = \ldots\,rad/s$$

Jawab.

➢ a)

$$\begin{aligned}\tau_1 &= |F_1| \cdot |r_1| \cdot \sin\theta \\ &= 2 \cdot 0 \cdot \sin 90° \\ &= 0\,Nm\end{aligned}$$ □

$$\begin{aligned}\tau_2 &= |F_2| \cdot |r_2| \cdot \sin\theta \\ &= 5 \cdot 0.5 \cdot \sin 60° \\ &= \frac{5}{4}\sqrt{3}\end{aligned}$$ □

$$\begin{aligned}\tau_3 &= |F_3| \cdot |r_3| \cdot \sin\theta \\ &= 7 \cdot 0.5 \cdot \sin 90° \\ &= 3.5\,Nm\end{aligned}$$ □

$$\begin{aligned}\tau_4 &= |F_1| \cdot |r_1| \cdot \sin\theta \\ &= 10 \cdot 0.5 \cdot \sin 0° \\ &= 0\,Nm\end{aligned}$$ □

$$\begin{aligned}\tau_{Fg} &= |F_g| \cdot |r_{Fg}| \cdot \sin\theta \\ &= (2 \cdot 9.8) \cdot 0.15 \cdot \sin 0° \\ &= 2.94\,Nm\end{aligned}$$ □

➢ b)

Sumbu simetri

$$\begin{aligned}I &= I_{pm} + Md^2 \\ &= \frac{1}{12}MR^2 + M\left(\frac{R}{2} - 0.2\right)^2 \\ &= \frac{1}{12}(2)(0.7)^2 + (2)\left(\frac{0.2+0.5}{2} - 0.2\right)^2 \\ &= \frac{19}{150}\,kg\,m^2\end{aligned}$$

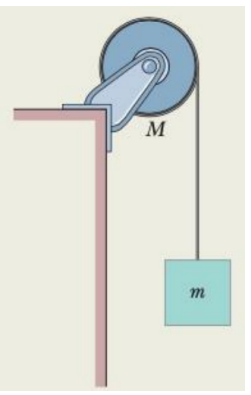
percepatan sudut

$$\begin{aligned}\Sigma\,\tau &= I\,\alpha \\ \tau_1 + \tau_2 + \tau_3 + \tau_4 &= I\,\alpha \\ \alpha &= \frac{\tau_1 + \tau_2 + \tau_3 + \tau_4 + \tau_{Fg}}{I} \\ &= \frac{0 + \frac{5}{4}\sqrt{3} + 3.5 + 0 + 2.94}{\left(\frac{19}{150}\right)} \\ &\approx 67.93\,rad/s^2\end{aligned}$$ □

➢ c)

$$\begin{aligned}{\omega_t}^2 &= {\omega_0}^2 + 2 \cdot \alpha \cdot \theta \\ &= 0 + 2 \cdot (67.93) \cdot \frac{\pi}{6} \\ \omega_t &= \sqrt{2 \cdot (67.93) \cdot \frac{\pi}{6}} \\ &= 8.43\,rad/s\end{aligned}$$ □

3. A pulley of uniform mass, $M = 2\,kg$ and radius $R = 10\,cm$, is mounted on a fixed horizontal shaft, as shown in the following figure. A block of mass $m = 1\,kg$ is suspended from a massless rope wrapped around the edge of a pulley. Calculate (Assume the rope does not slip, and there is no friction on the pulley shaft):
   (a) acceleration of falling block
   (b) angular acceleration of the pulley
   (c) tension of the rope

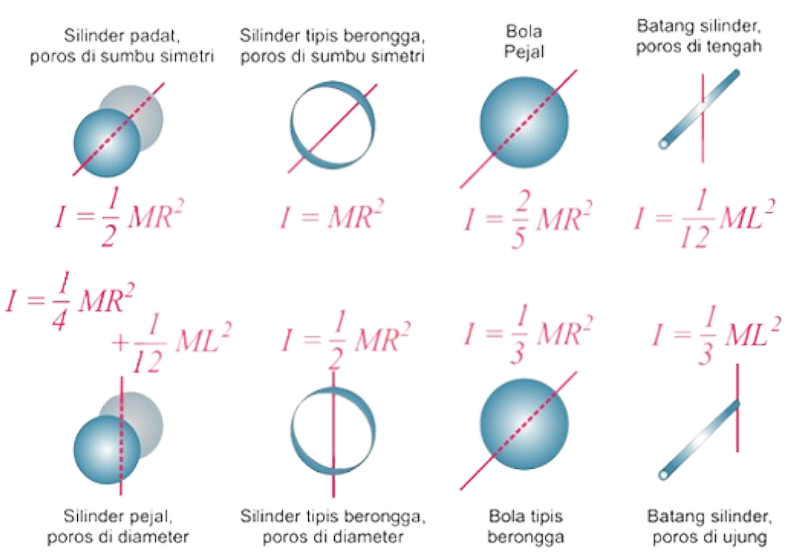


Materi: Benda

➢ *Torsi*

$$\tau = I\,\alpha$$

➢ *Tabel Momen Inersia*



Diketahui:

$$m_{katrol} = M = 2\,kg \qquad R_{katrol} = 10\,cm = 0.1\,m \qquad m_{balok} = m = 1\,kg$$

Ditanya:

$$a = \ldots\ m/s^2 \qquad \alpha = \ldots\ rad/s^2 \qquad T = \ldots\ N$$

Jawab.

➢ a)

percepatan sudut

$$a = \alpha \cdot R$$
$$\alpha = \frac{a}{R}$$

torsi pada katrol

$$\tau_{Katrol} = I\,\alpha$$
$$T \cdot R = \frac{1}{2}MR^2 \cdot \alpha$$
$$T = \frac{1}{2}MR^2 \cdot \frac{a}{R}$$
$$T = \frac{1}{2}M \cdot a$$

sumbu-y

$$\Sigma F_y = ma$$
$$F_g - T = ma$$
$$mg - \frac{M \cdot a}{2} = ma$$
$$mg = a\left(\frac{M}{2} + m\right)$$
$$a = \frac{mg}{\left(\frac{M}{2} + m\right)}$$
$$a = \frac{1 \cdot (9.8)}{\left(\frac{2}{2} + 1\right)}$$
$$= 4.9\ m/s^2 \qquad \square$$

➢ b) *Percepatan Sudut Katrol*

$$\alpha = \frac{a}{R}$$
$$= \frac{4.9}{0.1}$$
$$= 49\ rad/s^2 \qquad \square$$

➢ c) *Tegangan Tali*

$$T = \frac{1}{2}M \cdot a$$
$$= \frac{1}{2}(2) \cdot (4.9)$$
$$= 4.9\ N \qquad \square$$

4. Angular acceleration of a wheel $\alpha = 5t^4 - 6t^2\ rad/s^2$. At $t = 0$ s, the wheel has an angular velocity $\omega = 2\ rad/s$ and position $\theta = 1.5\ rad$. Find:
   (a) angular velocity equation ω (in rad/s) as a function of time t.
   (b) angular position θ (in rad) as a function of time t.
   (c) plot the angular velocity ω and angular position θ as a function of time t.

Materi: Benda

➢ *Gerak Melingkar*

$$\omega = \int \alpha\, dt \qquad \theta = \int \omega\, dt$$

Diketahui:

$$\omega_0 = 2\ rad/s \qquad \theta_0 = 1.5\ rad$$

Ditanya:

$$\omega = \ldots\ rad/s \qquad \theta = \ldots\ rad$$

Jawab.

➢ a)

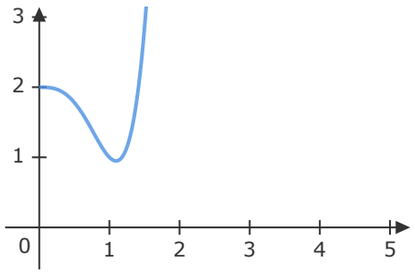
$$\begin{aligned}\omega &= \int \alpha\, dt \\ &= \int 5t^4 - 6t^2\ dt \\ &= t^5 - 2t^3 + \omega_0 \\ &= t^5 - 2t^3 + 2 \quad rad/s\end{aligned}$$ □

➢ b)

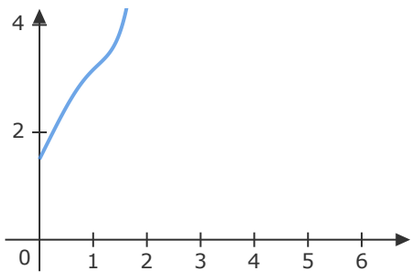
$$\begin{aligned}\theta &= \int \omega\, dt \\ &= \int t^5 - 2t^3 + 2\, dt \\ &= \frac{1}{6}t^6 - \frac{1}{2}t^4 + 2t + \theta_0 \\ &= \frac{1}{6}t^6 - \frac{1}{2}t^4 + 2t + 1.5 \quad rad\end{aligned}$$ □

➢ c)

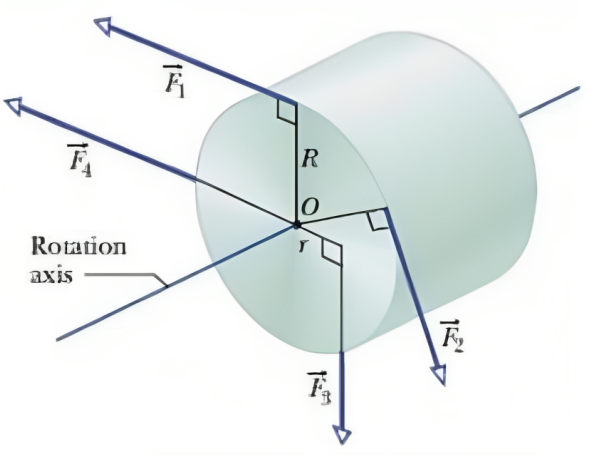
grafik kecepatan sudut



grafik posisi sudut



5. In the following figure, a $1.5\,kg$ cylinder is rotating about its main axis which passes through point O. Some forces which magnitudes are: $F_1 = 4\,N$, $F_2 = 3\,N$, $F_3 = 2\,N$, and $F_4 = 5\,N$ works on the cylinder in the direction as shown in tthe figure. If $r = 4\,cm$ and $R = 10\,cm$, and the relative angle of each force with respect to the cylinder does not change when the cylinder rotates, calculate:
   (a) the magnitude of total torque
   (b) the magnitude of angular acceleration
   (c) angular acceleration direction
   (d) moment of inertia when cylinder rotates about an axis passing through capture point of F_3 and parallel with the rotation axis.
   (e) the magnitude of angular acceleration of problem d.



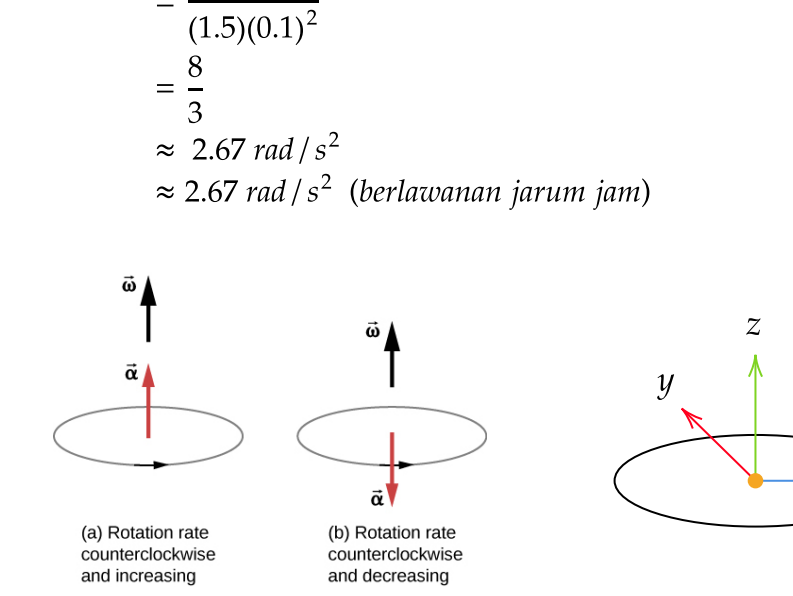
Materi: Benda Tegar

➢ *Torsi*

$$\tau = I\,\alpha$$

$$\Sigma\,\tau = \sum_{i=1}^{N} F_i\,r_i$$

➢ *Tabel Momen Inersia*



Diketahui:

$F_1 = 4\,N$ $\quad F_3 = 2\,N$ $\quad R = 10\,cm = 0.1\,m$ $\quad r = 4\,cm = 0.04\,m$ $\quad m = 1.5\,kg$
$F_2 = 3\,N$ $\quad F_4 = 5\,N$

Ditanya:

$\Sigma\,\tau = \ldots\,Nm$ $\quad \vec{\alpha} = \ldots\,rad/s^2$ $\quad I' = \ldots\,kg\,m^2$ $\quad \alpha_I{}' = \ldots\,rad/s^2$

Jawab.

➢ a)

$$\begin{aligned}
\Sigma\,\tau &= \sum_{i=1}^{N} F_i\,r_i \sin\theta \\
&= F_1\,r_1 \sin\theta - F_2\,r_2 \sin\theta - F_3\,r_3 \sin\theta + F_4\,r_4 \sin\theta \\
&= F_1\,R \sin 90° - F_2\,R \sin 90° - F_3\,r \sin 90° + F_4\,R \sin 0° \\
&= (4)(0.1)(1) - (3)(0.1)(1) - (2)(0.04)(1) + (5)(0.1)(0) \\
&= -0.02\,Nm \\
&= 0.02\,Nm \quad (\textit{searah jarum jam})
\end{aligned}$$

➢ b)

$$\begin{aligned}
\Sigma\,\tau &= I\,\alpha \\
\Sigma\,\tau &= \frac{1}{2}MR^2 \cdot \alpha \\
\alpha &= \frac{2 \cdot \Sigma\,\tau}{MR^2} \\
&= \frac{2 \cdot (0.02)}{(1.5)(0.1)^2} \\
&= \frac{8}{3} \\
&\approx 2.67\,rad/s^2 \\
&\approx 2.67\,rad/s^2 \quad (\textit{berlawanan jarum jam})
\end{aligned}$$

□

➢ c)

keluar ke bidang atau sumbu $+z$ □

➢ d)

$$\begin{aligned}
I &= I_{pm} + Md^2 \\
&= \frac{1}{2}MR^2 + Md^2 \\
&= M\left(\frac{1}{2}R^2 + d^2\right) \\
&= M\left(\frac{1}{2}R^2 + r^2\right) \\
&= (1.5)\left(\frac{1}{2}(0.1)^2 + (0.04)^2\right) \\
&= 0.0099\,kg\,m^2
\end{aligned}$$

□

➢ e)

$$\begin{aligned}
\Sigma\,\tau &= F_1\,r_1{}' \sin\theta' - F_2\,r_2{}' \sin\theta' - F_3\,r_3{}' \sin\theta' + F_4\,r_4{}' \sin\theta' \\
I\alpha &= F_1\,r_1{}' \sin\theta' - F_2\,(R - R\cos\theta) \sin\theta' - F_3\,r_3{}' \sin\theta' + F_4\,r_4{}' \sin\theta' \\
I\alpha &= 0 - (3)(10 - 10\cos\theta)' - 2(0.04)(1) \\
\alpha &= \frac{30 - 30\cos\theta - 0.08}{0.0099}
\end{aligned}$$

□

tidak dapat dihitung lebih lanjut karena tidak ada informasi besar θ *dari* F_2

6. There are four particles with masses and coordinates as follows: $m_1 = 25\,g$, $x_1 = 2\,cm$, $y_1 = 2\,cm$; $m_2 = 50\,g$, $x_2 = 0\,cm$, $y_2 = 4\,cm$; $m_3 = 30\,g$, $x_3 = -3\,cm$, $y_3 = -3\,cm$; and $m_4 = 25\,g$, $x_4 = -2\,cm$, $y_4 = 4\,cm$. Determine the moment of inertia of the particle system if the axis of rotation is:
   (a) $y = 1$
   (b) $x = 1$
   (c) $z - axis$

Materi: Benda Tegar

➢ *Momen Inersia*

$$I = mr^2$$

Diketahui:

$m_1 = 25\,g = 0.025\,kg$ $\quad m_2 = 50\,g = 0.05\,kg$ $\quad m_3 = 30\,g = 0.03\,kg$ $\quad m_4 = 25\,g = 0.025\,kg$

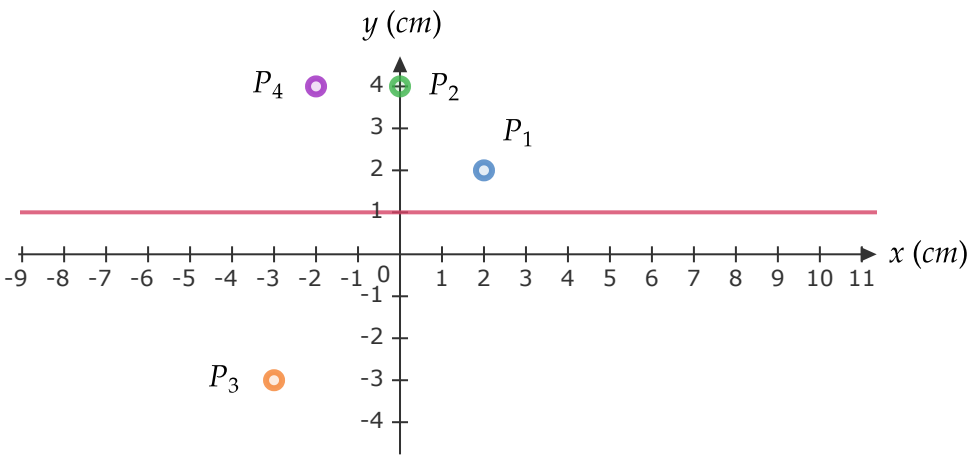
Ditanya:

$$\Sigma I = \ldots\ kg\ m^2$$

Jawab.

➢ a)

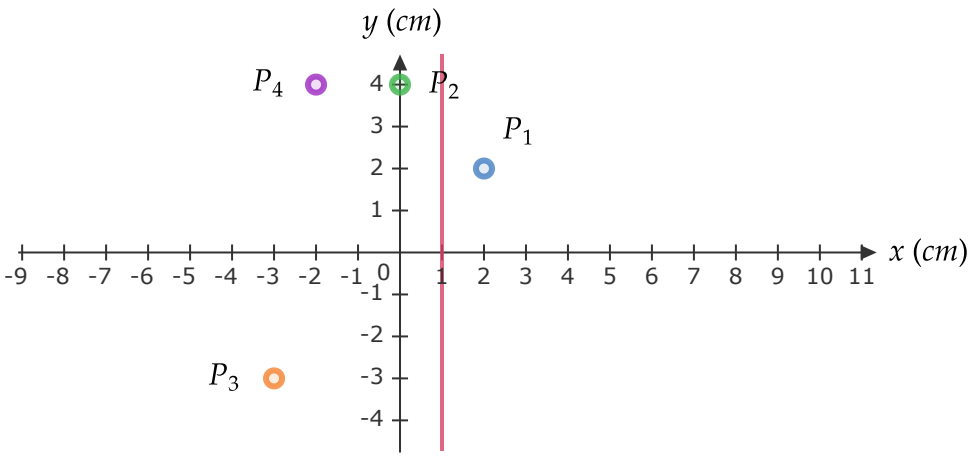
sumbu putar $y = 1$



$$\begin{aligned} I &= \Sigma I \\ &= I_1 + I_2 + I_3 + I_4 \\ &= m_1\, {r_1}^2 + m_2\, {r_2}^2 + m_3\, {r_3}^2 + m_4\, {r_4}^2 \\ &= (0.025)(0.01)^2 + (0.05)(0.03)^2 + (0.03)(0.04)^2 + (0.025)(0.03)^2 \\ &= 0.000118\ kg\ m^2 \end{aligned}$$ □

➢ b)

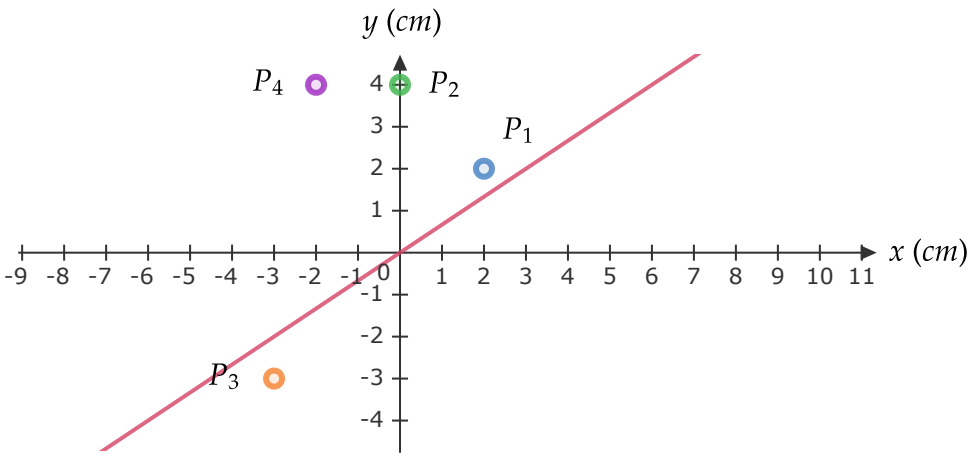
sumbu putar $x = 1$



$$\begin{aligned} I &= \Sigma I \\ &= I_1 + I_2 + I_3 + I_4 \\ &= m_1\, {r_1}^2 + m_2\, {r_2}^2 + m_3\, {r_3}^2 + m_4\, {r_4}^2 \\ &= (0.025)(0.01)^2 + (0.05)(0.01)^2 + (0.03)(0.04)^2 + (0.025)(0.03)^2 \\ &= 0.000078\ kg\ m^2 \end{aligned}$$ □

➢ c)

sumbu putar di sumbu z



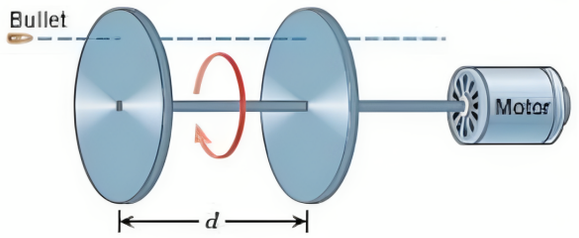
Pythagoras

$r_1^2 = (0.02)^2 + (0.02)^2 = 0.0008$ $\quad r_3^2 = (0.03)^2 + (0.03)^2 = 0.018$ $\quad r_3 = (0.02)^2 + (0.04)^2 = 0.002$

Momen Inersia

$$\begin{aligned} I &= \Sigma I \\ &= I_1 + I_2 + I_3 + I_4 \\ &= m_1\, {r_1}^2 + m_2\, {r_2}^2 + m_3\, {r_3}^2 + m_4\, {r_4}^2 \\ &= (0.025)(0.0008) + (0.05)(0.04)^2 + (0.03)(0.018) + (0.025)(0.002) \\ &= 0.00069\ kg\ m^2 \end{aligned}$$ □

7. In the following picture you can see a tool for determining the speed of a fired bullet. This tool consists of two discs, which can rotate on their axis with an angular speed of 100.0 rad/s, which are separated by a distance of $d = 0.5$ m. If a bullet penetrates the left disk first before penetrating the right disk, and the difference in the angular positions of the bullet holes in the two disks is $\theta = 0.25$ rad, determine the speed of the bullet



Materi: Benda

➢ *Gerak Lurus Beraturan*

$$s = vt \qquad \theta = \omega t$$

Diketahui:

$$s = d = 0.5\ m \qquad \theta = 0.25\ rad \qquad \omega = 100\ rad/s$$

Ditanya:

$$v_{peluru} = \ldots\ m/s$$

Jawab.

$$\begin{aligned} t_{peluru} &= t_{cakram} \\ \frac{d}{v} &= \frac{\theta}{\omega} \\ \frac{0.5}{v} &= \frac{0.25}{100} \\ v &= \frac{0.5 \cdot 100}{0.25} \\ &= 200\ m/s \end{aligned}$$

□

8. An object rotates about a fixed axis, and the angular position of a reference line on the object is given by $q = 0,4\, e^{2t}\ rad$. Consider a point on the object that is $4\ cm$ from the axis of rotation. At $t = 0\ s$, determine the magnitudes of:
   (a) angular velocity
   (b) tangential acceleration component
   (c) radial acceleration component

Materi: Benda

➢ *Gerak Lurus Beraturan*

$$s = vt \qquad \theta = \omega t$$

Diketahui:

$$r = 4\ cm = 0.04\ m \qquad t = 0\ s$$

Ditanya:

$$\omega = \ldots\ rad/s \qquad \alpha_t = \ldots\ rad/s^2 \qquad \alpha_s = \ldots\ rad/s^2$$

Jawab.

➢ a)

$$\begin{aligned}\omega(t) &= \frac{d\theta}{dt}\\ &= \frac{d}{dt}\left(0.4\, e^{2t}\right)\\ \omega(t) &= 0.8\, e^{2t}\\ \omega(0) &= 0.8\, e^{2(0)}\\ &= 0.8\ \ rad/s\end{aligned}$$ □

➢ b)

$$\begin{aligned}\alpha_t(t) &= \frac{d\omega}{dt}\cdot r\\ &= \frac{d}{dt}\left(0.8\, e^{2t}\right)\cdot 0.04\\ \alpha_t(t) &= 1.6\, e^{2t}\cdot 0.04\\ \alpha_t(0) &= 1.6\, e^{2(0)}\cdot 0.04\\ &= 1.6\cdot 0.04\\ &= 0.064\ rad/s^2\end{aligned}$$ □

➢ c)

$$\begin{aligned}\alpha_s &= \frac{v^2}{r}\\ &= \omega^2\, r\\ \alpha_s(t) &= \left(\frac{d\theta}{dt}\right)^2\cdot r\\ &= \left(\frac{d}{dt}\left(0.4\, e^{2t}\right)\right)^2\cdot 0.04\\ \alpha_t(t) &= \left(0.8\, e^{2t}\right)^2\cdot 0.04\\ \alpha_t(0) &= \left(0.8\, e^{2(0)}\right)^2\cdot 0.04\\ &= (0.8)^2\cdot 0.04\\ &= 0.0256\ rad/s^2\end{aligned}$$ □