

MOMENTUM & IMPULS

- momen (p) $\vec{p} = m \cdot \vec{v}$

- impuls ($\vec{\delta}$) $\Rightarrow \vec{\delta} = F \cdot \Delta t$

- Teorema Impuls Momenum
 $\vec{\delta} = \vec{\Delta p}$

$$\boxed{\vec{\delta} = \vec{F} \cdot \Delta t = m \vec{v}_f - m \vec{v}_i}$$

$\vec{p}_i, \vec{v}_i, \vec{\delta}, F$

VEKTOR

Gambar & arah

① DIK: $m: 0,40 \text{ kg}$

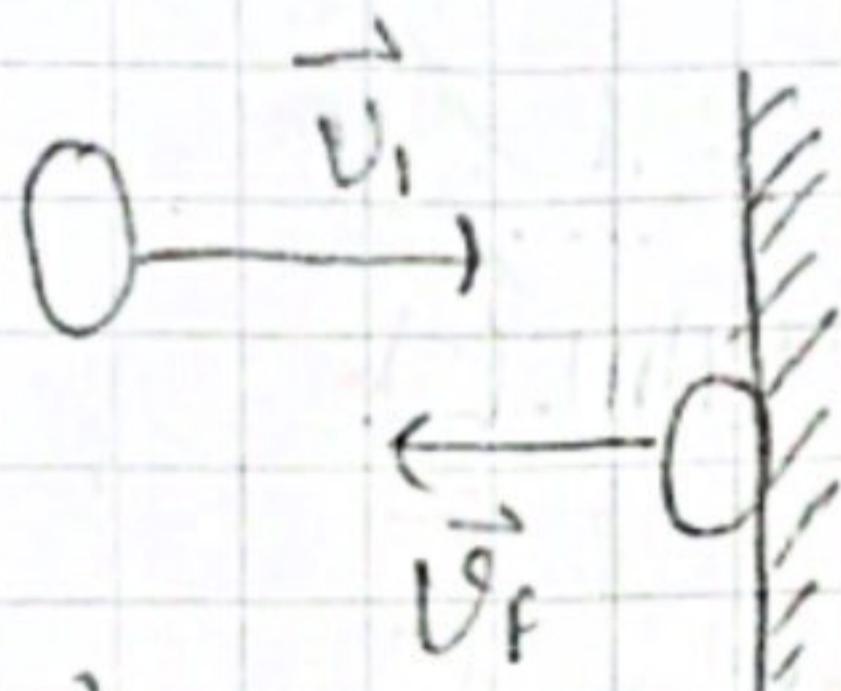
$v_i: 30 \text{ m/s}$

$v_f: 20 \text{ m/s}$

(a) $\vec{p}_i = ?$

$\vec{p}_f = ?$

(b) $\vec{\delta} = ?$



$v_i = 30 \text{ m/s}$

$v_f = -20 \text{ m/s}$

a) $\vec{p}_i = m \cdot \vec{v}_i$

$$= (0,4 \text{ kg}) \times (30 \text{ m/s})$$

$= 12 \text{ kg m/s}$

$p_f = m \cdot v_f$

$$= (0,4 \text{ kg}) \times (-20 \text{ m/s})$$

$= -8 \text{ kg m/s}$

b) $\vec{\delta} = m \cdot \vec{v}_f - m \cdot \vec{v}_i$

$$= -0 - 12 = -20 \text{ kg m/s}$$

↑ arah

$$\vec{v}_i = -30$$

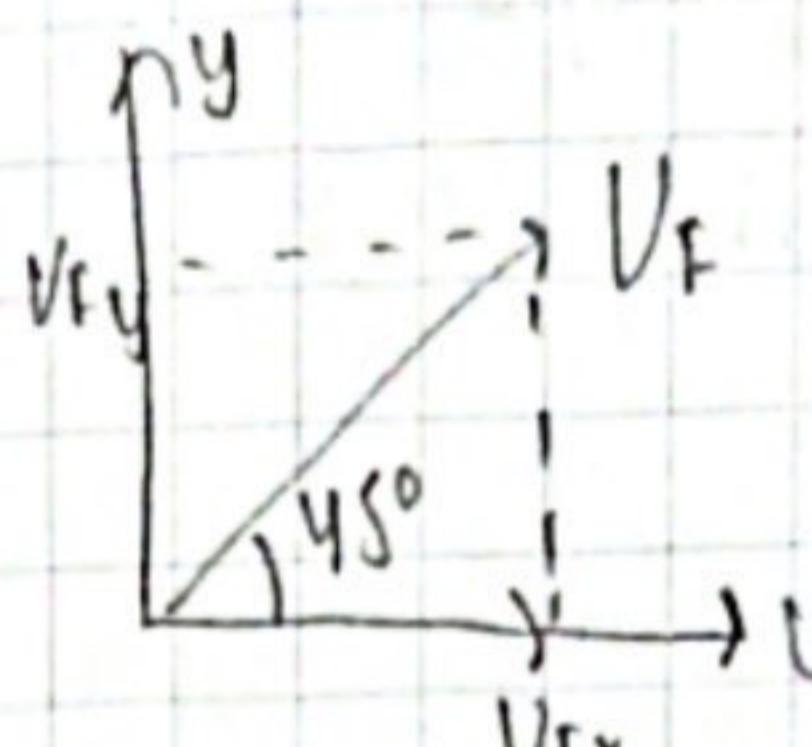
$$v_f = +20$$

$$\textcircled{2} \text{ DIK: } m = 0,40 \text{ kg}$$

$$\Delta t = 0,018$$

$$\vec{v}_i = -30 \frac{\text{m}}{\text{s}} \hat{i} \quad (i)$$

$$\vec{v}_f = v_x \hat{i} + v_{fx} \hat{e}$$



$$v_{fx} = v_f \cos 45^\circ = 30 \frac{1}{2} \sqrt{2}$$

$$= 15\sqrt{2} \text{ m/s}$$

$$v_{fy} = v_f \sin 45^\circ = 30 \frac{1}{2} \sqrt{2}$$

$$= 15\sqrt{2} \text{ m/s}$$

$$\vec{v}_f = 15\sqrt{2} \hat{i} + 15\sqrt{2} \hat{e} \text{ m/s}$$

a) $\vec{\delta} = ?$

$$\boxed{\vec{\delta} = m \cdot \vec{v}_f - m \cdot \vec{v}_i}$$

$$15\sqrt{2} = 21,21$$

$$= m(v_f - v_i)$$

$$= 0,40 [15\sqrt{2} \hat{i} + 15\sqrt{2} \hat{e} - (-20\hat{i})]$$

$$= 0,4 [21,21 \hat{i} + 21,21 \hat{e} - (-20\hat{i})]$$

$$= 16,40 \hat{i} + 8,40 \hat{e} \text{ kg m/s}$$

b) $F = ?$

$$\boxed{\delta = F \cdot \Delta t}$$

$$F = \frac{\delta}{\Delta t} = \frac{16,40 \hat{i} + 8,40 \hat{e}}{0,018}$$

$$= (1640 \hat{i} + 840 \hat{e}) \text{ N}$$

$$\text{Dik}: M = 0,5 \text{ kg}$$

$$V_i = (5\hat{i} + 8\hat{j}) \text{ m/s}$$

$$V_F = (-15\hat{i} - 7\hat{j} + 10\hat{k}) \text{ m/s}$$

Dit: a) perubahan kecepatan pada sumbu x, y & z!

$$|V_F - V_i|$$

$$(-15\hat{i} - 7\hat{j} + 10\hat{k}) - (5\hat{i} + 8\hat{j})$$

$$= -20\hat{i} - 8\hat{j} + 10\hat{k}$$

$$= -20(4)\hat{i}$$

$$= -8(4)\hat{j}$$

$$= 10(2)\hat{k}$$

b) Perubahan momentum!

$$P = M(V_F - V_i)$$

$$= 0,5 \text{ kg} (-20\hat{i} - 8\hat{j} + 10\hat{k})$$

$$= -10\hat{i} - 4\hat{j} + 5\hat{k}$$

c) HITUNG IMPULS bola!

$$\Delta P = \Delta p_i$$

$$\Delta P = F \cdot \Delta t$$

$$= -10\hat{i} - 4\hat{j} + 5\hat{k}$$

$$= 0,0028$$

besar gaya rata-rata pada bola!

$$\Delta P = F \cdot \Delta t$$

$$-10\hat{i} - 4\hat{j} + 5\hat{k} = F \cdot 0,0028$$

$$F = -5000\hat{i} - 2000\hat{j} + 2500\hat{k}$$

$$F = \frac{-10\hat{i} - 4\hat{j} + 5\hat{k}}{0,0028}$$

$$\text{Besar: } |\vec{F}| = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

$$= \sqrt{(-5000)^2 + (-2000)^2 + (2500)^2}$$

$$= 500\sqrt{141}$$

$$\approx 5932,17 \text{ N}$$

Konsep momentum

$$P_i = \vec{P}_F$$

Sistem partikel massa: $\sum m_i$

$$X_{pm} = \frac{\sum m_i v_i}{\sum m_i}$$

③ Kondisi awal (i)

$$M = 4 \text{ kg} \quad | \text{ sistem}$$

$$m = 0,01 \text{ kg}$$

$$v_i = 0$$

Kondisi akhir (F)

$$M = 4 \text{ kg} \rightarrow v_F = ?$$

$$m = 0,01 \text{ kg}$$

$$V_F = 0 \text{ m/s}$$

↑
konstan

Hukum Konservasi Momentum

$$P_i = \vec{P}_F$$

$$M \vec{V}_{si} + m \vec{V}_{pi} = M \vec{V}_{sf} + m \vec{V}_{pf}$$

$$\therefore 0 + 0 = (4) \vec{V}_{sf} + (0,01) / 300$$

$$0 = 4 V_{sf} + 3$$

$$-3 = 4 V_{sf}$$

$$\frac{-3}{4} = \vec{V}_{sf}/1$$

⑨ DRU: diam $\Rightarrow \vec{v}_i = 0$

$$M_{\text{proton}} = 1836 \text{ kali}$$

m_{elektron}

Dit: perbandingan dari energi total yang dilepaskan proton \rightarrow E. kinetik?

$$\Rightarrow \boxed{\vec{p}_i = \vec{p}_f}$$

$$M_i \vec{v}_i + M_f \vec{v}_f = M_i \vec{v}_i + M_f \vec{v}_f$$

Kondisi awal

Kondisi akhir

M_{neutron}

$$v_i = 0$$

$$\frac{E_{\text{total}}}{E_p} = ?$$

$$M_{\text{proton}} = M_p \quad M_p = 1836 \text{ Me}$$

$$M_{\text{elektron}} = m_e$$



$$m_e = \frac{M_p}{1836}$$

$$\vec{p}_i = \vec{p}_f$$

$$0 = \frac{M_p}{2} \vec{v}_{pf} + \frac{m_e}{2} \vec{v}_{ef}$$

$$0 = M_p \cdot v_{pf} + \frac{M_p}{1836} \cdot v_{ef}$$

$$\frac{M_p}{1836} \cdot v_{ef} = M_p \cdot v_{pf}$$

$$\frac{1}{1836} \vec{v}_{ef} = \vec{v}_{pf}$$

$$\vec{v}_{ef} = -1836 \vec{v}_{pf}$$

$$\frac{E_{\text{total}}}{E_p} = \frac{K_{pf} + K_{ef}}{K_{pf}}$$

$$= \frac{1}{2} M_p \cdot v_{pf}^2 + \frac{1}{2} m_e \cdot v_{ef}^2$$

$$\cancel{\frac{1}{2} M_p \cdot v_{pf}^2}$$

$$= \frac{M_p \cdot v_{pf}^2 + \frac{M_p}{1836} (-1836 \cdot v_{pf})^2}{M_p \cdot v_{pf}^2} = 1 + \frac{(1836)^2}{1836} = 1 + 1836 = 1837$$

③ Dik: $M = 75 \text{ kg}$ → orang

$m = 125 \text{ kg}$ → Perahu

$M = 15 \text{ kg}$ → Paket

horizontal ke kanan

$$v_i = 4,5 \text{ m/s}$$

abaikan hambatan udara,
perahu tidak bergerak
sebelum paket dilempar.

Dit: Tentukan kecepatan perahu!

by Kondisi awal (i) Kondisi akhir (f)

$$M_{\text{orang}} = 75 \text{ kg}$$

① Momentum awal = 0

② Kondisi akhir (setelah paket dilempar):

= Misalkan kecepatan perahu (berarteri orang di dalamnya) setelah paket dilempar $\Rightarrow v$.

Momentum akhir sistem terdiri =

- Momentum paket ke kanan =

$$m' \cdot v_i = 15 \text{ kg} \times 4,5 \text{ m/s}$$

$$= 67,5 \text{ kg m/s}$$

- Momentum perahu + Orang ke kiri =

$$(M+m) \cdot v = (75 \text{ kg} + 125 \text{ kg}) \cdot v$$

$$= 200 \text{ kg} \cdot v$$

- Berdasarkan huk. Konservasi =

$$0 = (200 \text{ kg}) \cdot v - 67,5 \text{ kg m/s}$$

$$200 \text{ kg} \cdot v = 67,5 \text{ kg m/s}$$

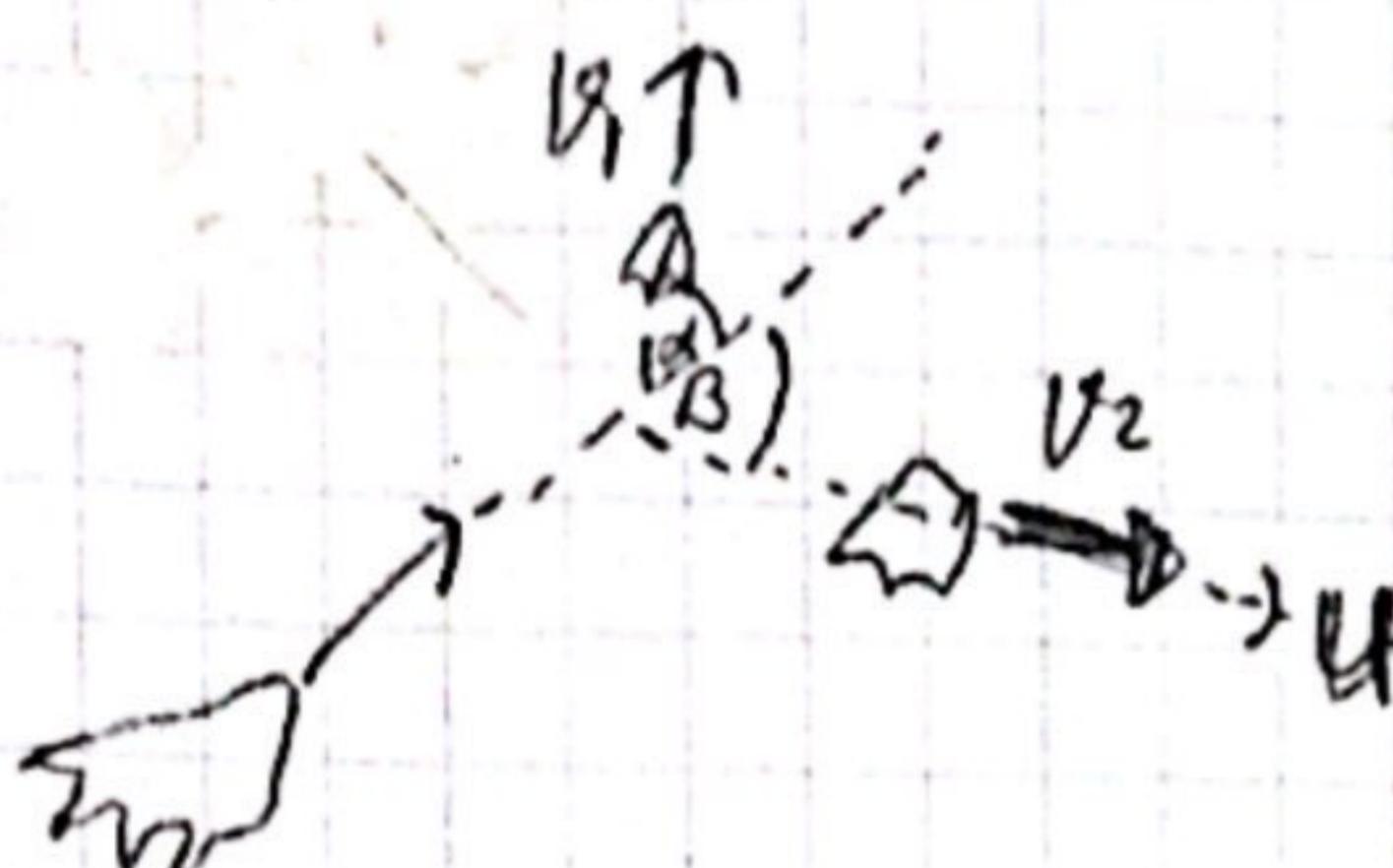
$$v = \frac{67,5}{200} = 0,3375 \text{ m/s}$$

⑥ Sabuk roti kambing api, bermassa m , $v_0 = 40 \text{ m/s}$ terpecah menjadi 2 bagian. Massanya sama.

Masing-masing bergerak v_1 & v_2 .

Dik: $\alpha = 30^\circ$

$$\beta = 60^\circ$$



Dit: a) tulis persamaan momentum linear!
b) Tentukan laju v_1 & v_2 !

c) Tentukan laju pm setelah pecah!

Jawab: a) $\vec{P}_I = \vec{P}_F$

$$m \cdot v_0 = m_1 \vec{v}_1 + m_2 \vec{v}_2$$

$$m(v_0 \hat{i} + v_0 \hat{j}) = \frac{1}{2} m v_1 \hat{i} + \frac{1}{2} m v_2 \hat{i}$$

$$(24 \hat{i} + 24\sqrt{3} \hat{j}) = \frac{1}{2} v_1 \hat{i} + \frac{1}{2} v_2 \hat{i}$$

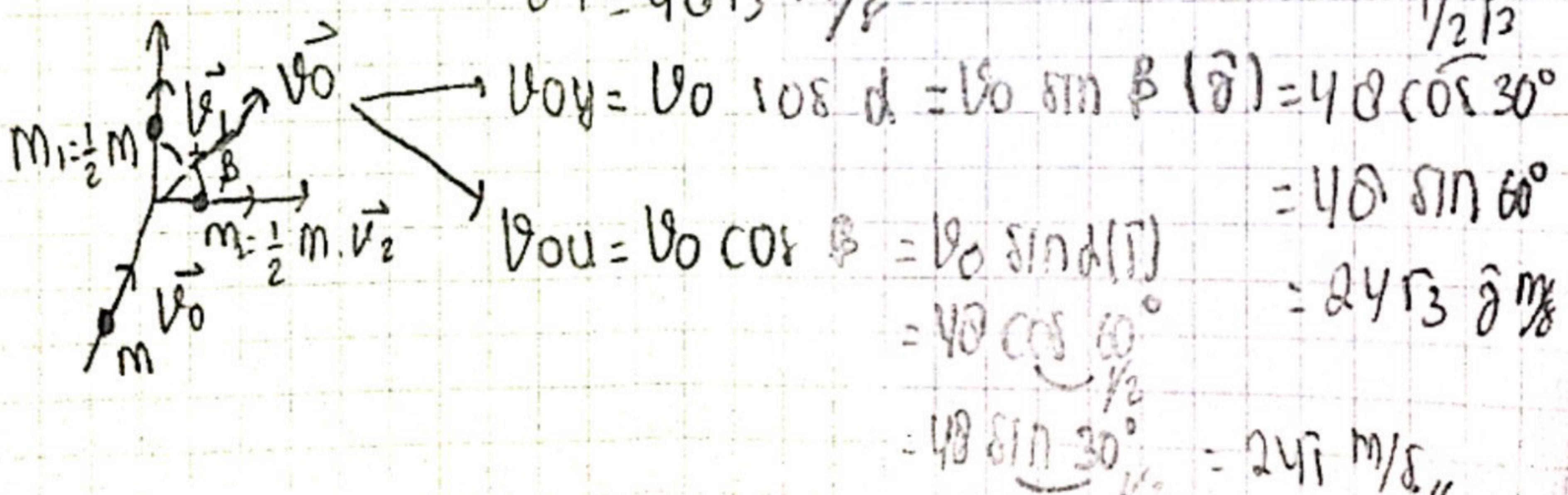
b) v_1 & $v_2 = ?$

$$\text{dari } \hat{i} \Rightarrow 24 \hat{i} = \frac{1}{2} v_2 \hat{i}$$

$$v_2 = 48 \text{ m/s}$$

$$\text{dari } \hat{j} \Rightarrow 24\sqrt{3} \hat{j} = \frac{1}{2} v_1 \hat{j}$$

$$v_1 = 48\sqrt{3} \text{ m/s}$$



c) Kecepatan pusat massa =

$$VPM = \frac{M_1 \cdot V_1 + M_2 \cdot V_2}{M_1 + M_2}$$

$$= \frac{\frac{1}{2} m \cdot 40\sqrt{3} \hat{r} + \frac{1}{2} m \cdot 40\hat{z}}{M_1 + M_2}$$

$$= \frac{\frac{1}{2} m + \frac{1}{2} m}{1m} \underline{= 24\sqrt{3} \hat{r} + 24\hat{z}}$$

$$= 24\sqrt{3} \hat{r} + 24\hat{z} \text{ m/s}$$

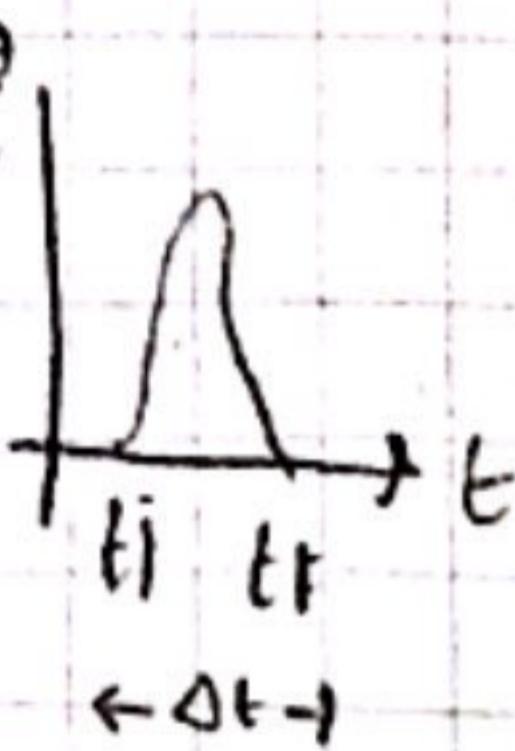
MOMENTUM dan IMPULS

kinematika, dinamika, usaha & energi, momenntum

IMPULS = Perkalian antara gaya rata-rata yang bekerja

$$\vec{J} = \vec{F} \cdot \Delta t$$

$$\vec{J} = \int_{t_i}^{t_f} \vec{F} dt$$



(satuan = Nm)

Momentum linear:

$$\vec{P} = m \cdot \vec{v}$$

$$\vec{P} = m \vec{v}$$

satuan = kg, m/s

vector

$$\begin{aligned} \vec{P} &= P_x \hat{i} + P_y \hat{j} + P_z \hat{k} \\ &= m v_x \hat{i} + m v_y \hat{j} + m v_z \hat{k} \end{aligned}$$

HUKUM II Newton:

$$\sum \vec{F} = m \cdot \vec{a}$$

$$= m \frac{d\vec{v}}{dt}$$

massa partikel konstan =

$$\sum \vec{F} = \frac{d(m\vec{v})}{dt}$$

$$\sum \vec{F} = \frac{d\vec{P}}{dt}$$

Teorema Impuls & momentum:

$$\vec{F} = m \cdot \vec{a}$$

$$= m \cdot \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

$$\vec{F} \cdot \Delta t = m \vec{v}_f - m \vec{v}_i$$

$$\vec{F} \cdot \Delta t = m \vec{v}_f - m \vec{v}_i$$

$$\vec{F} \cdot \Delta t = m \vec{v}_f - m \vec{v}_i$$

Impuls

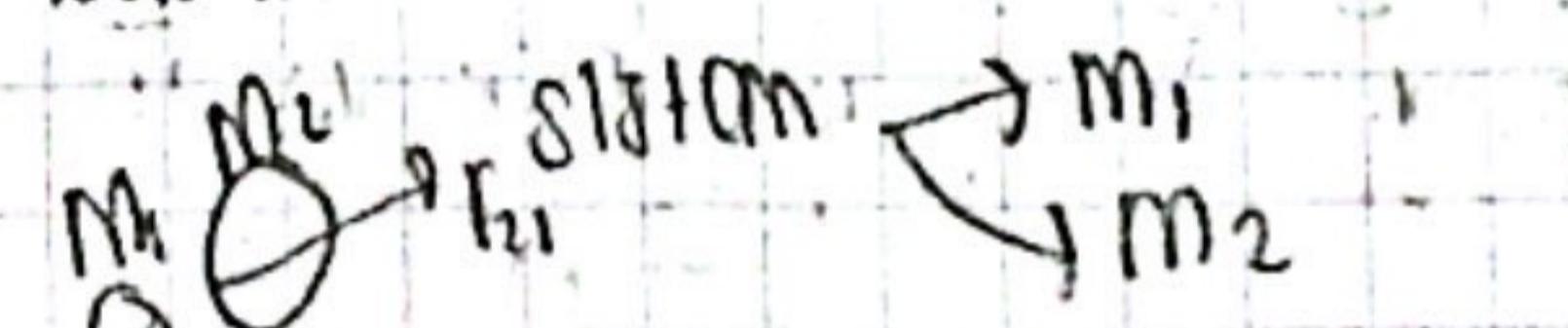
perubahan momentum

$$\vec{J} = \vec{P}_f - \vec{P}_i$$

Teorema Impuls - Momentum:

"Impuls = Δmomentum"

Konsekuensi Momentum linear:



$\Rightarrow f_{12} \& f_{21}$ = gaya cuaca reaksi

$$\sum \vec{F}_{out} = 0$$

$$\frac{\Delta \vec{P}}{\Delta t} = 0$$

$$\Delta \vec{P} = 0$$

$$\vec{P}_f - \vec{P}_i = 0$$

$$\vec{P}_i = \vec{P}_f \quad \leftarrow$$

$$m v_i = m_1 v_{1f} + m_2 v_{2f}$$

Sistem Partikel

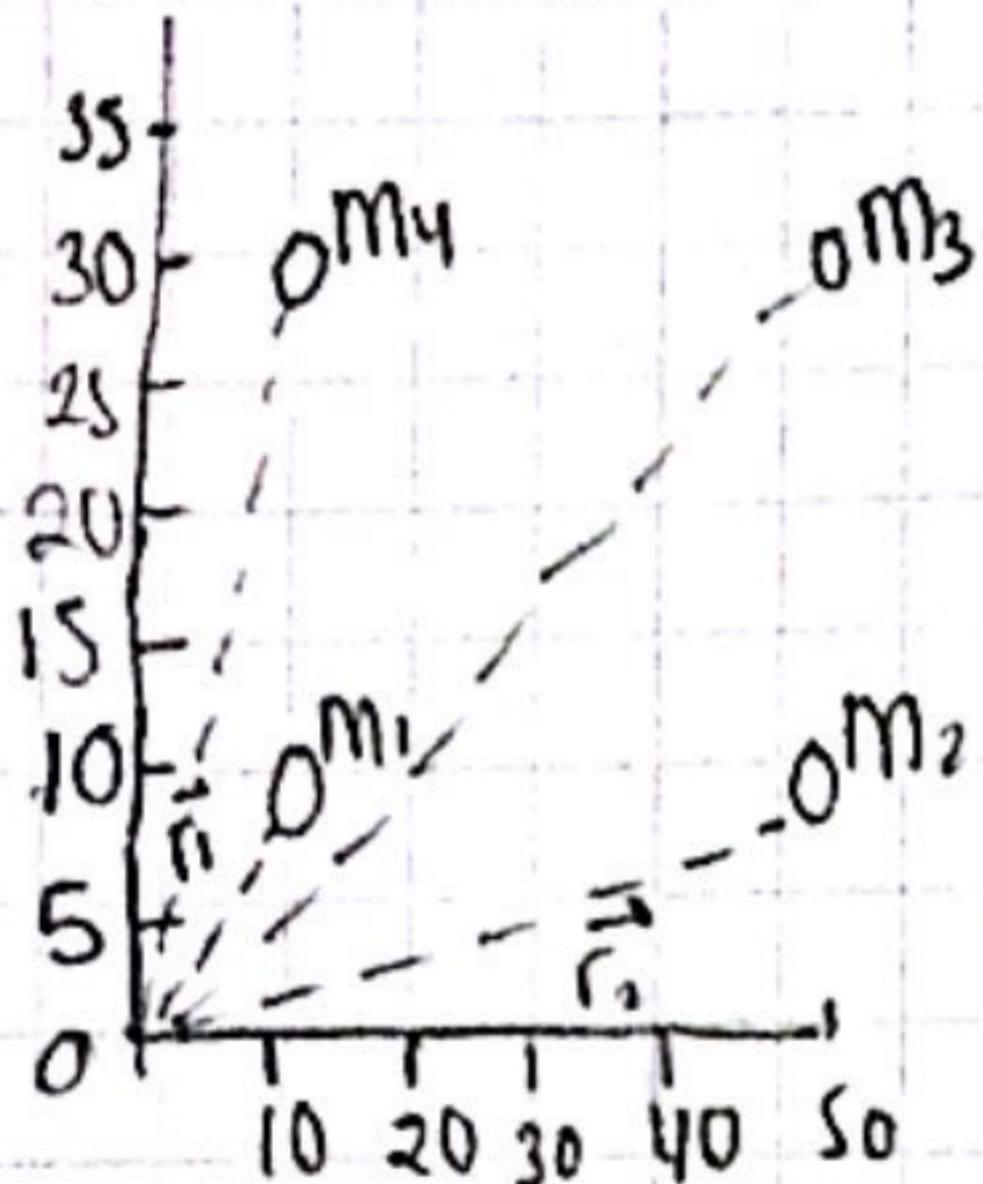
Analisis gerak benda:

↳ gerak benda rumit

↳ bentuk & ukuran benda diperhitung

↳ $\sum F_{\text{luar}} \rightarrow$ berikan partikel

Sistem Benda Disusun:



$$\bar{U}_{\text{pm}} = M_1 \cdot U_1 + M_2 \cdot U_2 + M_3 \cdot U_3 + M_4 \cdot U_4$$

$$= \frac{M_1 \cdot U_1 + M_2 \cdot U_2 + M_3 \cdot U_3 + M_4 \cdot U_4}{M_1 + M_2 + M_3 + M_4}$$

$$\bar{Y}_{\text{pm}} = M_1 \cdot Y_1 + M_2 \cdot Y_2 + M_3 \cdot Y_3 + M_4 \cdot Y_4$$

$$= \frac{M_1 \cdot Y_1 + M_2 \cdot Y_2 + M_3 \cdot Y_3 + M_4 \cdot Y_4}{M_1 + M_2 + M_3 + M_4}$$

Sistem benda kontinu:

$$\bar{U}_{\text{pm}} = \frac{1}{M} \int \vec{r} dm$$

1-D -> 1D
(Rapat massa per satuan panjang)

$$\lambda = \frac{dm}{du}$$

$$\bar{U}_{\text{pm}} = U_{\text{pm}}^1$$

$$\bar{U}_{\text{pm}} = \frac{\int u du}{S \lambda du}$$

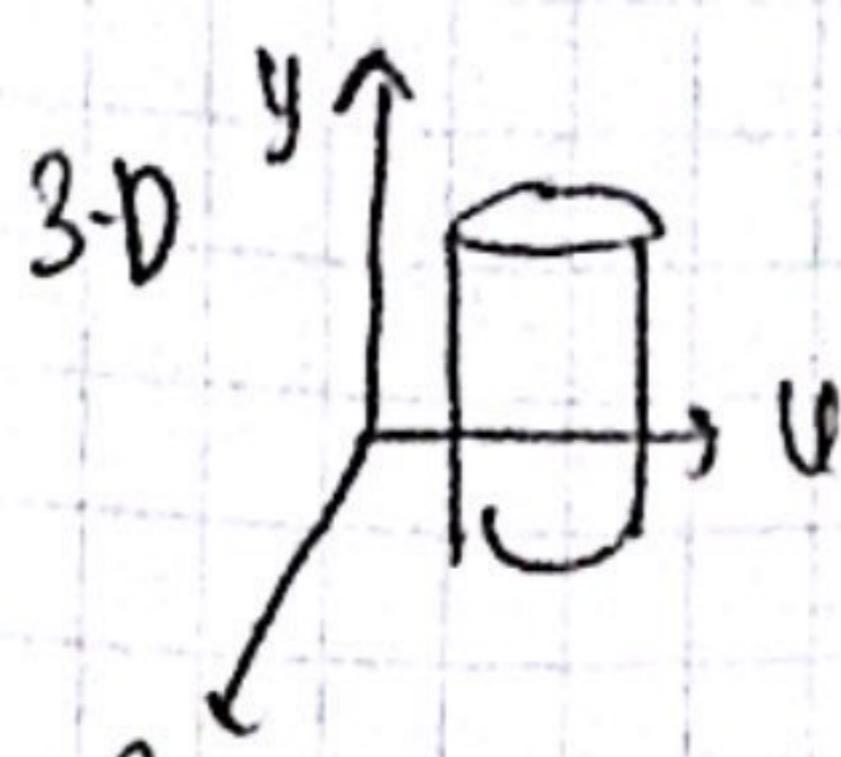
2-D
(Rapat massa per satuan luas)

$$\sigma = \frac{dm}{da}$$

$$\bar{U}_{\text{pm}} = U_{\text{pm}}^1 + Y_{\text{pm}}^1$$

$$U_{\text{pm}} = \frac{\int \sigma u da}{\int \sigma da}$$

$$Y_{\text{pm}} = \frac{\int \sigma y da}{\int \sigma da}$$



2) Rapat massa per volume:

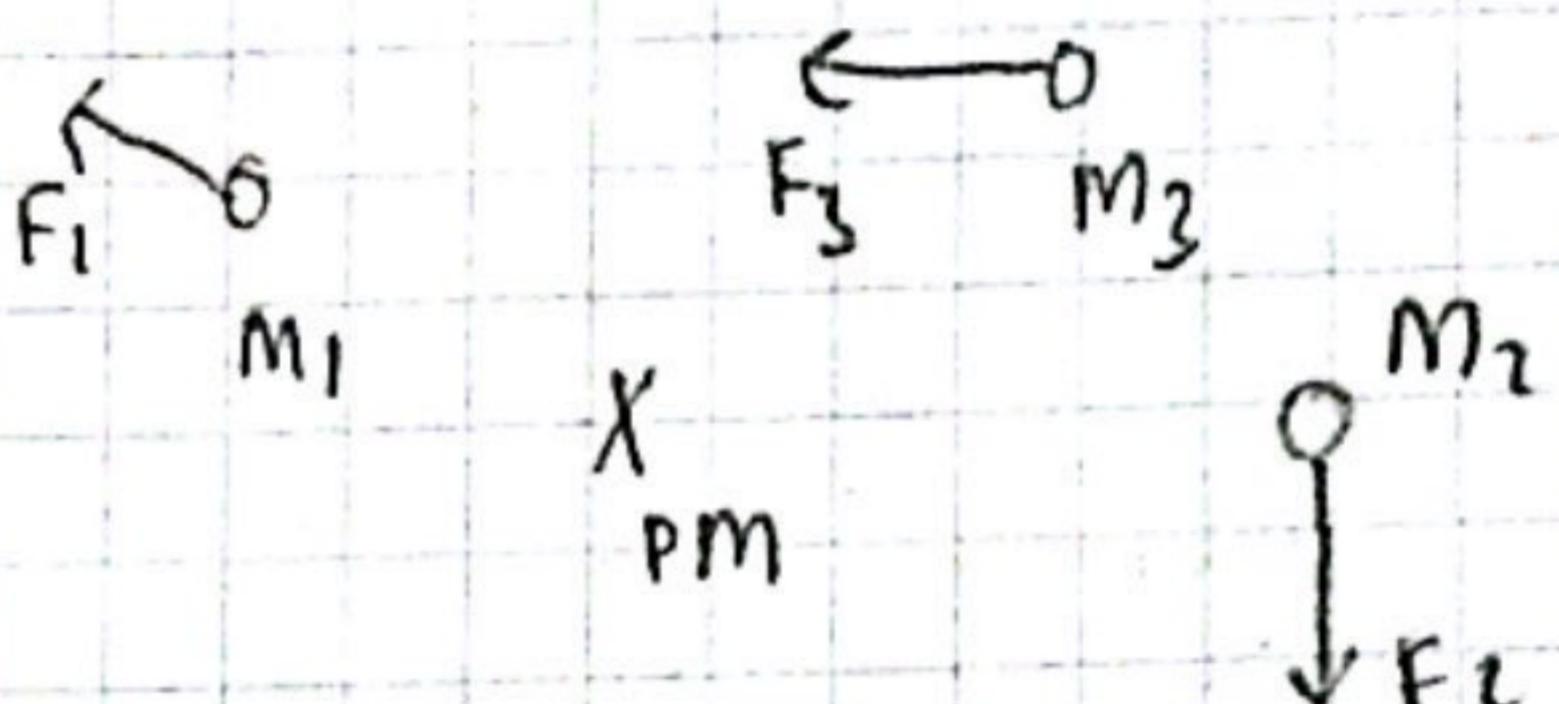
$$\rho = \frac{dm}{dv}$$

$$\bar{U}_{\text{pm}} = U_{\text{pm}}^1 + Y_{\text{pm}}^1 + Z_{\text{pm}}^1$$

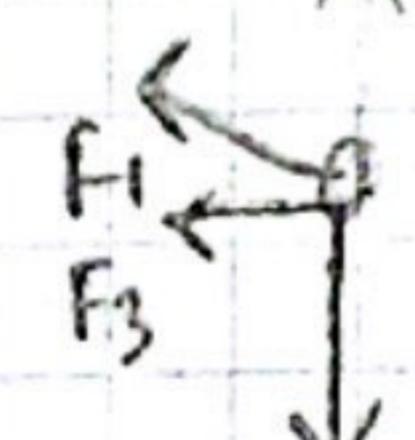
$$U_{\text{pm}} = \frac{\int p_x dv}{\int \rho dv} \quad Y_{\text{pm}} = \frac{\int p_y dv}{\int \rho dv}$$

$$Z_{\text{pm}} = \frac{\int p_z dv}{\int \rho dv}$$

I. KILM II Newton $\frac{d}{dt} \vec{U}_{\text{pm}}$
PARTIKEL



#9a perlu dijawab 1-1
(pusat massa)



$$\sum F = M \cdot \ddot{U}_{\text{pm}}$$

RUMUS = $\sum F = M \cdot \ddot{U}_{\text{pm}}$

M = total massa sistem kontinu

$\ddot{U}_{\text{pm}} = \text{Percepatan pusat massa}$

tumbukan

tumbukan \rightarrow elastik
atau inelastik

PIORITAS = momentum linear total:

$$P_{1i} + P_{2i} = P_{1F} + P_{2F}$$

- EK tot sistem kekal

$$K_{1i} + K_{2i} = K_{1F} + K_{2F}$$

tau PIORITAS = momentum linear total:

$$P_{1i} + P_{2i} = P_{1F} + P_{2F}$$

- EK tot sistem tidak kekal:

$$K_{1i} + K_{2i} = K_{1F} + K_{2F}$$

Kloss

tumbukan tau elastik (1-D)

Ktotal akhir < Ktotal awal

$$\frac{1}{2} m_1 v_{1F}^2 + \frac{1}{2} m_2 v_{2F}^2 < \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2$$

momentum sistem tetap kekal:

$$m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} = m_1 \vec{v}_{1F} + m_2 \vec{v}_{2F}$$

tumbukan tau elastik satuan

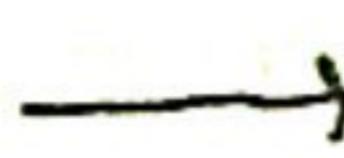
sebalik:

$$v_f = \frac{m_1 \vec{v}_{1i} + m_2 \cdot \vec{v}_{2i}}{m_1 + m_2}$$

arah

$+(-)$

$$(+v_i) - \underline{0} \leftarrow \underline{0} - (-v_i)$$



sumbu U^+

tumbukan

ID

$v_{10f} = 0$

Tumbukan Dalam 2-D

sumbu U :

$$m_1 v_{1i} u + m_2 v_{2i} u = m_1 v_{1Fu} + m_2 v_{2Fu}$$

$$m_1 \cdot v_{1i} \cos \theta + m_2 \cdot v_{2i} \cos \beta =$$

$$m_1 \cdot v_{1i} \cos \theta + m_2 \cdot v_{2i} \cos \theta$$

sumbu Y :

$$m_1 v_{1i} y + m_2 v_{2i} y =$$

$$m_1 \cdot v_{1Fy} + m_2 \cdot v_{2Fy}$$