Solusi Tutorial 4 Fisika Dasar 1A ITB

oleh: Wawan k

A. Pertanyaan

① Tidak, karena $\vec{I} = \vec{F}\Delta t$

Impuls tidak hanya bergantung pada $\vec{F}$ tetapi Δt juga.

② Momentum kekal, berarti momentum sebelum tumbukan = momentum sesudah tumbukan.

$$P_i = P_f$$

atau $$P_f - P_i = 0$$

$$\Delta P = 0$$

kita ketahui bahwa, $\Sigma F = \frac{dP}{dt}$ sebagai bukti $F = \frac{d}{dt}(mV)$

$$= m\frac{dV}{dt}$$

$$F = m.a$$

maka jika $\Sigma F = 0$,

$$\frac{dP}{dt} = 0$$

sehingga P = konstanta = konstanta

Jadi P kekal, maka $\Sigma F = 0$

untuk (a) $\Sigma F_x = 6 - 6 = 0$

$\Sigma F_y = 3 - 2 = 1$ $\Sigma F_y \neq 0$

Jadi, P_x = kekal, dan P_y tidak kekal

•) untuk (b)

$$\Sigma F_x = (5 + 8\cos 60^\circ) - 3 - 2 - 8\cos 60^\circ$$

$$\Sigma F_x = 0$$

$$\Sigma F_y = 8\sin 60^\circ + 8\sin 6^\circ = 4 + 4 = 8\ N$$

•) untuk arah x, P_x → kekal

arah y, P_y → tidak kekal

•) untuk c

$$\Sigma F_x = 5 + 6\cos 60^\circ - 4 - 6\cos 60^\circ = 1\ N$$

$$\Sigma F_y = 6\sin 60^\circ - 6\sin 60^\circ = 0$$

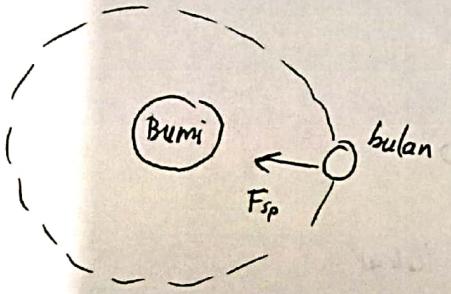
•) untuk arah x → P_x tidak kekal

•) untuk arah y → P_y → kekal

(3) bola memantul dilantai

Bola berarah kebawah (pusat bumi) dan bumi bergerak keatas (berlawanan dengan arah bola) karena gaya gravitasi, Karna kedua benda saling bertumbukan, dan terpisah (setelah tumbukan), maka momentum linearnya kekal.

(4)



Momentum linear bulan tidak kekal, karena ada gaya sentripetal (gaya gravitasi - bumi - bulan), sehingga $\Sigma F \neq 0$.

④ karena kelajuan bulan konstan, maka E_k selalu konstan.

Sehingga Energi kinetiknya kekal

⑤ a) Tidak mungkin,

karena kasus ini hanya terjadi jika,

$$P_i = P_f$$

$$P_1 - P_2 = 0$$

artinya $P_1 = P_2$

Kecepatan pada soal $V_2 = 0$

b) Mungkin, kasus ini terjadi jika $m_1 = m_2$, sehingga akan terjadi pertukaran kecepatan.

Contohnya: $P_i = P_f$

$$m_1 v_1 + 0 = m_2 v_2 + 0$$

$$v_1 = v_2$$

B. SOAL

① Impuls = perubahan momentum

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

$$\vec{F}_{avg}\,\Delta t = m(\vec{v}_f - \vec{v}_i)$$

$$-\vec{F}_{avg}\,\Delta t = m(\vec{v}_f - \vec{v}_i)$$

$$v_f = \frac{mv_i - F_{avg}\,\Delta t}{m}$$

$$v_f = 33{,}5 - 91{,}86$$

$$v_f = (-58{,}36\ \hat{i})\ m/s$$

② $P_i = P_f$

$$m_p v_i + 0 = m_p v_p' + m_b v_b'$$

$$(23)(230) = (23)(170) + 2000\,(v_b)$$

$$v_b = \frac{5290 - 3910}{2000} = \frac{1380}{2000} = 0{,}69\ m/s$$

(3) a) $J = \int F\,dt$ = luas di bawah kurva F-t

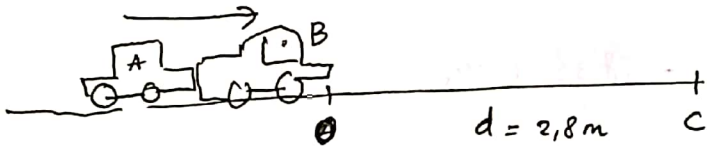
$$I = \frac{1}{2}(1{,}5 \times 10^{-3})(18000) = 13{,}5\ NS$$

b) $$F_{avg} = \frac{I}{\Delta t} = \frac{13{,}5\ kNs}{1{,}5 \times 10^{-3}\ s} = 9\ kN$$

c) Dari grafik kita ketahui, $F_{maks} = 18\ kN$

(4) Gaya gesek kedua mobil adalah

$$f_{ges} = \mu_k (m_A + m_B) g$$



Setelah tumbukan, misalkan kedua mobil telah menempuh OC

maka : $W_{ext} = \Delta + W_{gesek}$

$$0 = \Delta K + \Delta U + W_{gesek}$$

$$0 = K_f - K_i + W_{gesek}$$

$$= 0 - \frac{1}{2}mV^2 + W_{gesek}$$

$$W_{gesek} = \frac{1}{2}(m_A + m_B)V^2$$

$$\mu_k (m_A + m_B) g\, d = \frac{1}{2}(m_A + m_B)V^2 \longrightarrow V = \sqrt{2\mu_k g d} = \sqrt{(0{,}8)(2)(9{,}8)(2{,}8)}$$

$$V = 6{,}6\ m/s$$

(4) Kecepatan kedua mobil tersama setelah tumbukan adalah

$$V = 6{,}6\ m/s$$

Kemudian, kita gunakan kekekalan momentum,

$$P_i = P_f$$

$$m_A V_A = (m_A + m_B) V$$

$$920\, V_A = (920 + 2300)(6{,}6)$$

$$V_A = \frac{21252}{920} = 23\ m/s$$

(5) a) $P_i = P_f$ Asumsikan anak diam setelah naik perahu.

$$m_1 V_1 + 0 = (m_1 + m_2) V$$

maka : $m_1 V_1 = (m_1 + m_2) V$

$$V = \frac{m_1 V_1}{m_1 + m_2} = \frac{14\,(8{,}9\ m/s)}{14 + 160} = \frac{124{,}6}{174} = 0{,}7\ m/s$$

b) Energi hilang $= Ek_f - Ek_i$

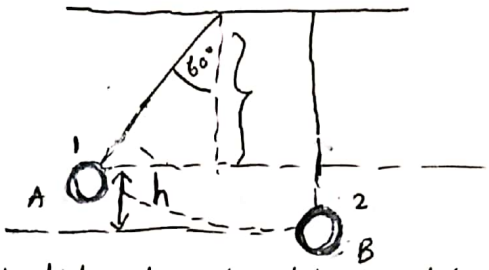
$$= \frac{1}{2}(m_1 + m_2) V^2 - \frac{1}{2} m_1 V_1^2$$

$$= \frac{1}{2}(174)(0{,}7)^2 - \frac{1}{2}(14)(8{,}9)^2$$

$$= 42{,}53 - 554{,}47 = -511{,}94\ J$$

Energi hilang akibat gesekan anak dengan perahu.

(6)



Terlebih dahulu kita hitung kecepatan bola 1 dititik B sebelum menumbuk bola 2,

$$EM_A = EM_B$$

$$mgh + 0 = \frac{1}{2}mV_1^2 + 0$$

$$g(L - L\cos\theta) = \frac{1}{2}V_1^2$$

$$gL(1 - \cos\theta) = \frac{1}{2}V_1^2$$

$$V_1^2 = 2gL(1 - \cos\theta)$$

$$V_1 = \sqrt{2(9{,}8)(1{,}15)(1 - \cos 60^\circ)}$$

$$V_1 = 3{,}8 \text{ m/s}$$

Karena tumbukan bersifat elastik, maka :

$$V_{1f} = \frac{m_1 - m_2}{m_1 + m_2} V_{1i} = \frac{1 - 1{,}5}{1 + 1{,}5}(3{,}8) = 0{,}76 \text{ m/s}$$

$$V_{2f} = \frac{2m_1}{m_1 + m_2} V_{1i} = \frac{2(1)}{1 + 1{,}5}(3{,}8) = 3{,}04 \text{ m/s}$$

(6) b) Setelah tumbukan, kita tinjau bola 1

$EM_B = EM_C$

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}v^2 = g(L - L\cos\theta)$

$= gL(1 - \cos\theta)$

$\frac{v^2}{2gL} = 1 - \cos\theta$

$\cos\theta = 1 - \frac{v^2}{2gL}$

$= 1 - \frac{(3,8)^2}{2(9,8)(1,5)}$

$= 1 - \frac{14,44}{29,4}$

$= 0,50$

$\theta = \cos^{-1}(0,50)$

$\theta = 60^\circ$

(7) Posisi pusat massa :

$$\vec{x}(t) = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$

$$= \frac{(1)(2t) + (3)(2) + (2)(-3)}{1+3+2}$$

$$= \frac{2t + 6 - 6}{6}$$

$$x(t) = \frac{1}{3} t \, \hat{i}$$

$$\vec{y}(t) = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3}$$

$$= \frac{(1)(3t^2 - 2) + (3)(t)^2 + (2)(-4t)}{6}$$

$$= \frac{(3t^2 - 2) + 3t^2 - 8t}{6}$$

$$= \frac{6t^2 - 8t - 2}{6}$$

$$\vec{y}(t) = \left(t^2 - \frac{4}{3}t - \frac{1}{3}\right)\hat{j}$$

$$z(t) = \frac{m_1 z_1 + m_2 z_2 + m_3 z_3}{m_1 + m_2 + m_3}$$

$$= \frac{(1)(4t^2) + (3)(0) + (2)(-t)}{6}$$

$$\vec{z}(t) = \frac{4t^2 - 2t}{6} = \left(\frac{2}{3}t^2 - \frac{1}{3}t\right)\hat{k}$$

b) $F = 2t\,\hat{i}$ → benda ketiga dikenai F

(i) percepatan pusat massa setelah 4 detik setelah dikenai gaya

Jika benda 3 dikenai $F = 2t\,\hat{i}$, maka benda 3 mengalami percepatan

sebesar : $\vec{a}_3(t) = \frac{\vec{F}(t)}{m_3} = \frac{2t}{1,2} = 1,67t\,\hat{i}\ m/s^2$

$\vec{a}_3(2) = 1,67(4) = 6,7\ m/s^2\,\hat{i}\ m/s^2$

maka percepatan pusat massa :

$$a_{x\,pm} = \frac{m_1 a_{x1} + m_2 a_{x2} + m_3 a_{x3}}{M}$$

$$= \frac{0 + 0 + 1,2(6,7)}{2,5}$$

$$a_{x\,pm} = 3,2\ m/s^2\,\hat{i}$$

$$a_{y\,pm} = \frac{m_1 a_{1y} + m_2 a_{2y} + m_3 a_{y3}}{M} = 0\ m/s^2$$

jadi, percepatan pusat massa, $(3,2, 0)\ m/s^2$

(c) Posisi benda ke 3 setelah $t = 4s$, posisi x akan berubah karena $\vec{F}$

$$\Delta x_3 = \int V_0 + V\,dt$$

$$x_3(4) - x_3(0) = \int_0^4 V_0 + \left[\int a\,dt\right] dt$$

$V = 0$

$$= \int_0^4 V_0 + \left(\int 1,67t\,dt\right) dt$$

$$x_3(4) - 2 = \int_0^4 0,835t^2\,dt = 0,278t^3\Big|_0^4 = 17,8$$

(7) Jadi, posisi pusat massanya adalah :

$$\vec{r}_{pm} = \frac{1}{3}t\hat{i} + \left(t^2 - \frac{4}{3}t - \frac{1}{3}\right)\hat{j} + \left(\frac{2}{3}t^2 - \frac{1}{3}t\right)\hat{k}$$

b) kecepatan titik pusat massa

$$v_{pm} = \frac{d\vec{r}_{pm}}{dt} = \left[\frac{1}{3}\hat{i} + \left(2t - \frac{4}{3}\right)\hat{j} + \left(\frac{4}{3}t - \frac{1}{3}\right)\hat{k}\right] \text{ m/s}$$

c) percepatan titik pusat massa,

$$a_{pm} = \frac{dv_m}{dt} = \left[2\hat{j} + \frac{4}{3}\hat{k}\right] \text{ m/s}^2$$

(8) a) Posisi pusat massa (x_{pm}, y_{pm})

$$x_{pm} = \frac{m_A x_A + m_B x_B + m_C x_C}{M}$$

$$= \frac{(0{,}15)(0) + 0{,}8(0) + 1{,}2(2)}{2{,}5}$$

$$x_{pm} = 0{,}96 \text{ m}$$

$$y_{pm} = \frac{m_A y_A + m_B y_B + m_C y_C}{M} = \frac{(0{,}15)(0) + (0{,}8)(2) + 1{,}2(2)}{2{,}5}$$

$$y_{pm} = 1{,}6 \text{ m}$$

Jadi, posisi pusat massa adalah $(0{,}96 ; 1{,}6)$ m

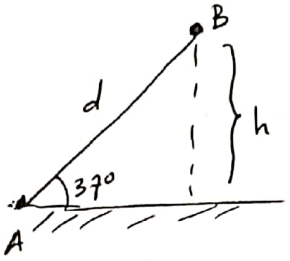
(3) a) $P_i = P_f$

$m_1 v_1 + 0 = (m_1 + m_2) V$

$V = \dfrac{m_1 v_1}{m_1 + m_2}$

$V = \dfrac{5(8)}{5+3} = \dfrac{40}{8} = 5 \text{ m/s}$

b)



Asumsikan, sistem berhenti pada titik B.

$\sin\theta = \dfrac{h}{d} \rightarrow h = d \sin\theta$

pada lintasan AB, $W_{eksternal} = \Delta EM_{AB} + W_{gesek}$

$0 = EM_B - EM_A + W_{gesek}$

$EM_A = EM_B + W_{gesek}$

$\frac{1}{2} m V_A^2 = mgh + \mu_k mg\cos\theta \cdot d$

$\frac{1}{2}(m_1+m_2)V^2 = (m_1+m_2) d\sin\theta + \mu_k (m_1+m_2) g\cos\theta\, d$

$\frac{1}{2} V^2 = d\sin\theta + \mu_k g d\cos\theta$

$\frac{1}{2} V^2 = d(\sin\theta + \mu_k g \cos\theta)$

$d = \dfrac{V^2}{2(\sin 37^\circ + \mu_k g \cos 37^\circ)}$

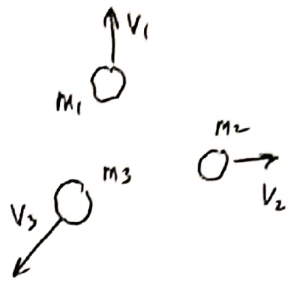
(9) $$d = \frac{5^2}{2\{0,6 + 0,25(9,8)(0,8)\}}$$

$$d = 4,9 \text{ m}$$

(10) $m_0 = 17 \times 10^{-27}$ kg $V_i = 0$ (induk)

$m_1 = 5 \times 10^{-27}$ kg $V_1 = 6 \times 10^6 \hat{j}$ m/s

$m_2 = 8,4 \times 10^{-27}$ kg $V_2 = 4 \times 10^6 \hat{i}$ m/s



a) $m_1V_1 + m_2V_2 + m_3V_3 = 0$

dimana $m_3 = m_0 - m_1 - m_2 = 3,6 \times 10^{-27}$ kg

maka, $(5 \times 10^{-27})(6 \times 10^6 \hat{j}) + (8,4 \times 10^{-27})(4 \times 10^6 \hat{i}) + (3,6 \times 10^{-27}) V_3 = 0$

$$V_3 = (-9,33 \times 10^6 \hat{i} - 8,33 \times 10^6 \hat{j}) \text{ m/s}$$

b) $E = \frac{1}{2} m_1V_1^2 + \frac{1}{2} m_2V_2^2 + \frac{1}{2} m_3V_3^2$

$$= \frac{1}{2}\left[(5 \times 10^{-27})(6 \times 10^6)^2 + (8,4 \times 10^{-27})(4 \times 10^6)^2 + (3,6 \times 10^{-27})(12,5 \times 10^6)^2\right]$$

$$\boxed{E = 4,39 \times 10^{-13} \text{ J}}$$

Good luck