

Mechanics

Chapter 4: Collisions (Classwork)

Solutions

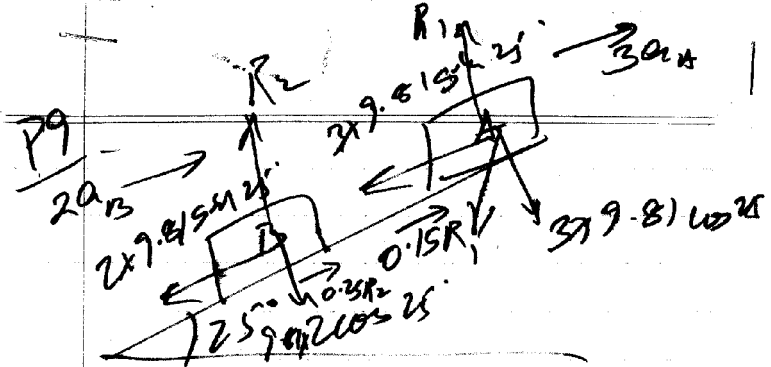
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Collision
Class Work



$$\sum F_y = 0$$

$$R_2 = \cancel{2a_B}$$

$$2 \times 9.81 \cos 25^\circ$$

$$\sum F_{x0} = 0$$

$$2a_B + 0.25R_2 = 2 \times 9.81 \sin 25^\circ$$

$$\therefore a_B = 1.923 \text{ m/s}^2$$

$$\sum F_y \uparrow = 0 \quad \therefore R_1 = 3 \times 9.81 \cos 25^\circ$$

$$\sum F_{x4} = 0 \quad \therefore 3a_A + 0.15R_1 = 3 \times 9.81 \sin 25^\circ$$

$$\therefore a_A = 2.812 \text{ m/s}^2$$



<p>Let time be t s dist of A = $10 + x$ & B = x</p> <p>$s = ut + \frac{1}{2}at^2$</p> <p>$10 + x = \frac{1}{2} \times 2.812 t^2$</p> <p>$x = \frac{1}{2} \times 2.812 t^2 - 10$ — (1)</p> <p>$s = ut + \frac{1}{2}at^2$</p> <p>$x = 0 + \frac{1}{2} \times 1.923 \times t^2$ — (2)</p> <p>$\frac{1}{2} \times 2.812 t^2 - 10 = \frac{1}{2} \times 1.923 t^2$</p> <p>$\therefore t = \underline{4.743s}$</p>	<p style="text-align: right;">$v = u + at$</p> <p>Sub in (1) $x_B = 21.629m$ $x_A = 31.629m$</p> <p>$v_A = 13.337 \frac{m}{s}$ $v_B = 9.121 \frac{m}{s}$</p> <p>$M_A v_A + M_B v_B = M_A v_A' + M_B v_B'$</p> <p>10 + 0 $3 \times 13.337 + 2 \times 9.121 = 3v_A' + 2v_B'$</p> <p>$e = -\left(\frac{v_B' - v_A'}{v_B - v_A}\right)$ — (1)</p> <p>$-0.75(9.121 - 13.337) = v_B' - v_A'$</p> <p>$v_A' = 10.386 \frac{m}{s}$ $v_B' = 13.548 \frac{m}{s}$</p>
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POWER

By $\Delta PE_1 + \Delta KE_1 = \Delta PE_2 + \Delta KE_2$
 $0.2 \times 9.81 \times 25 + \frac{1}{2} \times 0.2 \times 25^2$
 $= 0 + \frac{1}{2} \times 0.2 v^2$
 $\therefore v = 33.399 \text{ m/s}$

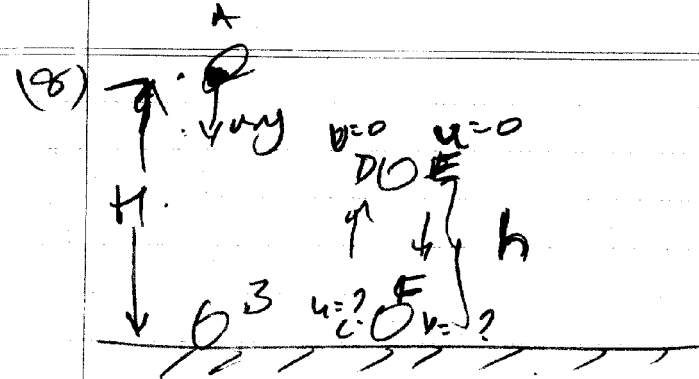
$v = u - gt$
 $\therefore t = \frac{v - u}{-g} = \frac{26.719 - 25}{-9.81} = 0.1735 \text{ s}$
 $s = ut = 26.719 \times 0.1735 = 4.63723 \text{ m}$
 $e = \frac{-v'}{-33.399}$
 $v' = 26.719 \text{ m/s}$
 $33.399 \text{ m/s} = 25 \cos 30^\circ$
 $\therefore \theta = 40.409^\circ$

Vertical
 $s = ut - \frac{1}{2}gt^2$
 $0 = 26.719 - \frac{1}{2} \times 9.81 t^2$
 $\therefore t = 1.0778 \text{ s}$
 Horiz $s = ut = 26.719 \times 1.0778 = 28.81 \text{ m}$

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$$\begin{array}{r} \text{Total time} = 3.867 \\ + 4.148 \\ \hline 8.0155 \end{array}$$

$$\begin{array}{r} \text{Dist } n = 83.723 \\ - 71.845 \\ \hline 11.878 \text{ m} \end{array}$$



$$\frac{v^2 - v_B^2}{v^2} = u^2 + 2gh$$

$$\therefore v = \sqrt{2gh}$$

$$\therefore \frac{u^2}{g} = \sqrt{2gh}$$

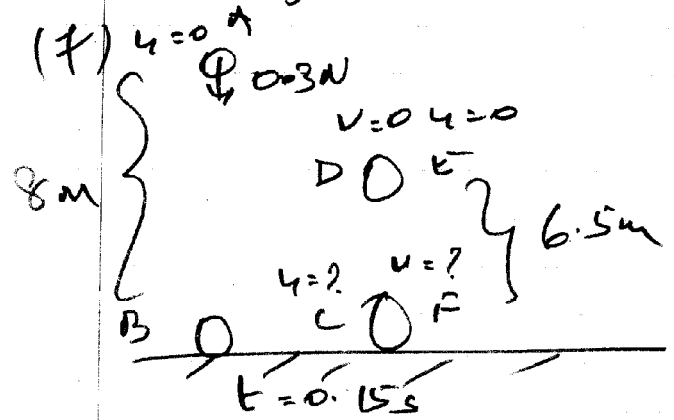
$$\therefore e = - \frac{v_B}{v}$$

$$\therefore v_B = - \frac{v_B}{e} \sqrt{2gh}$$

A-B
 $v^2 = u^2 + 2gh$
 $\frac{v}{e} = 0 + 2gH$
 $\therefore v = e\sqrt{2H}$

$I = F \times t$
 $= mv - mu$
 $= m [v_c - v_B]$
 ~~$= m \left[\sqrt{2gh} - \left(\frac{\sqrt{2gh}}{e} \right) \right]$~~
 ~~$= \dots$~~

$= m \left[\sqrt{2gh} + \frac{\sqrt{2gh}}{e} \right]$
 $= m\sqrt{2gh} \left[\frac{1+e}{e} \right]$
 $= m\sqrt{2gH} e \left[\frac{1+e}{e} \right]$
 $= m\sqrt{2gH} (1+e)$



<p>(a)</p> $\frac{E-F}{v^2 = u^2 + 2gh}$ $v = \sqrt{0 + 2 \times 9.8 \times 6.5}$ $\therefore v = 11.293 \text{ m/s}$ $\therefore \text{CP } u = 11.293$ $\therefore e = \frac{mv^2}{2}$ $\therefore \text{CP } e$ $\frac{v^2 = u^2 + 2gh}{\therefore v = 12.528 \text{ m/s}}$	$\therefore e = -\frac{v_c}{v_b}$ $e = -\frac{11.293}{-12.528}$ $e = 0.901$ <p>(b)</p> $I = mv_c - m v_b$ $= \frac{0.3}{9.81} [11.293 - (-12.528)]$ $= 0.728 \text{ kg m/s}$ <p>(c)</p> $I = Ft$ $\therefore F = I/t = 4.856 \text{ N}$
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(d) $v=0$

-11.293 m/s

\downarrow FO 40

$e = -\frac{v_u}{-11.293}$

$\therefore v_u = 10.175 \text{ m/s}$

AT $v^2 = u^2 - 2gh'$

$\therefore h' = 5.277 \text{ m}$

(6)

$t=1$
 $u=0$

15.189

\downarrow

15 m

$t=0$ $u=15 \text{ m/s}$

For A

$s = ut - \frac{1}{2}gt^2$

$15 = 15t - \frac{1}{2} \times 9.81 t^2$

\therefore From ① & ②

$u = u_a = 14.7346 \text{ m/s}$

$t = 1.2326 \text{ s}$

$v_A = u - gt$

$= 5.9081 \text{ m/s}$

For B

$s = ut + \frac{1}{2}gt^2$

$15 = 0 + \frac{1}{2} \times 9.81 (t-1)^2$

$t_B = 0.2654 \text{ s}$

$v_B = u + g(t-1)$

$= 2.2518 \text{ m/s}$



POWER

Q. C = 1.

$$M_A V_A + M_B V_B = M_A V_A' + M_B V_B'$$

$$0.4(5.9081) + 0.3(2.2818) = 0.4V_A' + 0.3V_B'$$

↳ (1)

$$e = - \frac{(V_A' - V_B')}{5.9081 + 2.2818}$$

$$\therefore V_B' - V_A' = 8.1899 \quad \text{--- (2)}$$

From (1) & (2)

$$V_B' = -1.1118 \text{ m/s}$$

$$V_A' = 7.0781 \text{ m/s}$$

$v = 0$

Q_2

$v = 4 - gt$

$$0 = 7.0781 - 9.81t$$

$$\therefore t = 0.7215 \text{ s}$$

$v = 0$

Q_1

2.5535 m

14.7346 m

$g = ut + \frac{1}{2}gt^2$

$$17.2881 = 0 + \frac{1}{2} \times 9.81 t^2$$

$$\therefore t = 1.8774 \text{ s}$$

total time =

$$0.7215 + 1.8774 = 2.5989 \text{ s}$$

for beginning =

$$2.5989 + 1.2351 = 3.834 \text{ s}$$

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$$\frac{A-B}{v_x} = \sqrt{2g \times h} = 8.8589 \text{ m/s}$$

$$v^2 = u^2 + 2gh$$

$$u = \sqrt{2 \times 9.8 \times 2.5}$$

$$v_c = 7.004 \text{ m/s}$$

$$e = \left(\frac{+7.004}{-8.8589} \right) = 0.7906$$

$$v_c = v_f = \sqrt{2 \times 9.8 \times 4} = 8.8589 \text{ m/s}$$

$$v_g = v_j = \sqrt{2 \times 9.8 \times 1.75} = 5.831 \text{ m/s}$$

$$e = \frac{5.831}{8.8589} = 0.658$$

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(4)

$v = 0$ $4 = 0$

A

$\frac{1}{4} v_0$

1.2m

4m

$e = 0.75$

B O O E

$V_c = \sqrt{2 \times 9.81 \times 4}$
 $= 8.8589 \text{ m/s}$

$e = -\frac{V_c}{V_B}$

$0.75 = -\frac{8.8589}{V_B}$

$V_B = -\frac{8.8589}{0.75}$
 $V_B = -11.812 \text{ m/s}$

$11.812^2 = v_0^2 + 2g(1.2)$
 $\therefore v_0 = 10.469 \text{ m/s}$



POWER

(1)

$e = 0$

$$\frac{400 \times 10^3 (2)}{9.81} + \frac{200 (10^3) (-5)}{9.81} = \frac{600 \times 10^3 (v')}{9.81}$$

$$\therefore v' = -0.333 \text{ m/s}$$

% loss in KE = $\frac{\frac{1}{2} \frac{400 \times 10^3 \times 2^2}{9.81} + \frac{1}{2} \frac{200 \times 10^3 \times 5^2}{9.81} - \frac{1}{2} \frac{600 \times 10^3 \times (0.333)^2}{9.81}}{100} = 98.99\%$

(2)

$$0.6 \times 4 + 0.3(-1) = 0.6 v_A' + 0.3 v_B'$$

$$v_A' = 1 \text{ m/s } (\rightarrow)$$

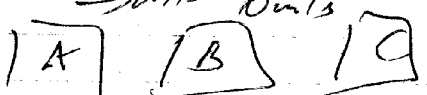
$$e = -\left(\frac{+5 - 1}{-1 - 4}\right)$$

$$e = 0.8$$

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(1) $e = 0.7$

→ starts 0 m/s



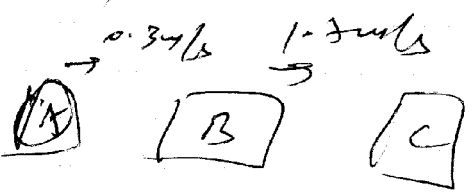
$m_A(2.5) + m_B(0) = m_A(u_A') + m_B(u_B')$
 $u_A' + u_B' = 2 \quad \text{--- (1)}$

$0.7 = -\left(\frac{u_A' - u_B'}{2 - 0}\right)$

$\therefore u_B' - u_A' = 1.4 \quad \text{--- (2)}$

From (1) & (2)

$u_A' = 0.3 \text{ m/s}$
 $u_B' = 1.7 \text{ m/s}$



By 2nd law

$m_C(1.7) + m_C(0) = m_C(u_C') + m_C(u_B')$
 $u_C' + u_B' = 1.7 \text{ m/s} \quad \text{--- (3)}$

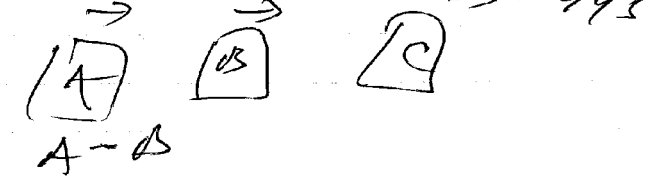
$0.7 = \left(\frac{u_C' - u_B'}{1.7 - 0}\right)$

$u_C' - u_B' = 1.19 \quad \text{--- (4)}$

From (3) & (4)

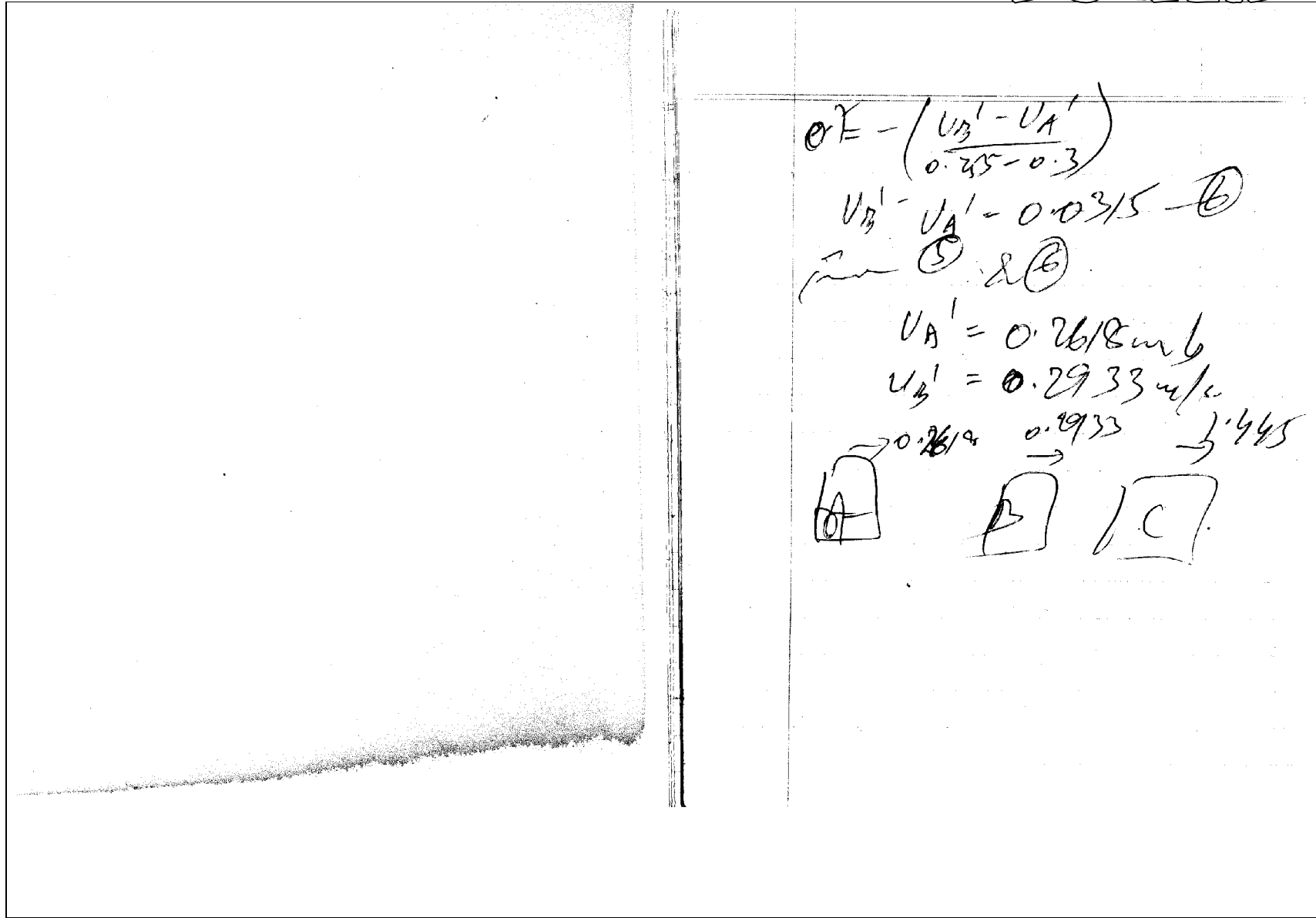
$u_B' = 0.255 \text{ m/s}$
 $u_C' = 1.445 \text{ m/s}$

$\rightarrow 0.3 \quad \rightarrow 0.255 \quad \rightarrow 1.445$



A - B

$m_A(0.3) + m_B(0.255) = m_A(u_A') + m_B(u_B')$
 $u_A' + u_B' = 0.555 \quad \text{--- (5)}$



$$e^x = - \left(\frac{V_B' - V_A'}{0.25 - 0.3} \right)$$

$$V_B' - V_A' = 0.0315 \text{ --- (6)}$$

from (5) & (6)

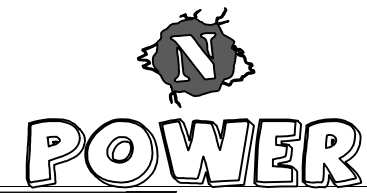
$$V_A' = 0.2618 \text{ mV}$$

$$V_B' = 0.2933 \text{ mV}$$

→ 0.2618 0.2933 → 0.445

A B C

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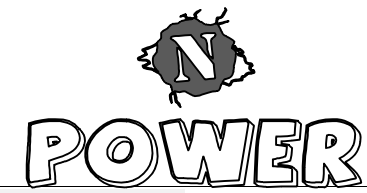
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