807 AP Physics
Name:____________________

Schmidt

U5H1

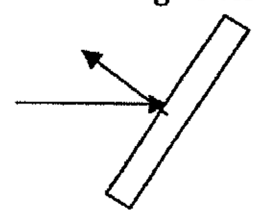
Momentum $\vec{p} = m\vec{v}$; $\Delta\vec{p} = \vec{p}_f - \vec{p}_i = \int \vec{F}(t)dt$; Impulse $\vec{J} = \int \vec{F}(t)dt$

Chapter 9: Impulse and Linear Momentum

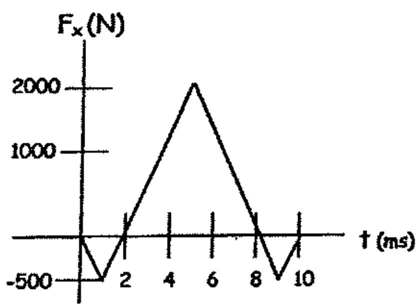
Momentum and Impulse are VECTORS !

1.A ball of 0.1 kg in horizontal flight to the right moves with a speed 50 m/s and hits a bat held vertically. The ball reverses its direction and moves with the same speed as before. Find the impulse that acts on the ball during its contact with the bat. If the time of contact is 1 milli-second, then find the average force that acts on the ball during its contact with the bat. (-10Ns,-10,000 N)

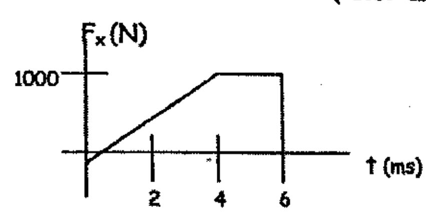
2. A ball of 0.1 kg in horizontal flight moves with a speed 50 m/s and is deflected by a bat as shown in the figure at an angle with horizontal. As a result, the ball is reflected at 50 m/s in a direction, making 45° with the horizontal. Find the impulse that acts on the ball during its contact with the bat.
(9.24 Ns @157.5°)



3. A Force vs. time graph is shown below. What impulse does the force exert on a 250 g particle? (5 Ns)

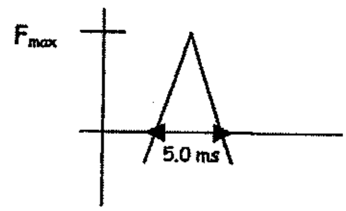


4. A 3.0 kg particle moving along the negative x-axis with a speed of 2m/s experiences the force shown. What is its speed and direction after the force ends? (-0.67 m/s)



5. A sled slides along a horizontal surface on which the coefficient of kinetic friction is 0.25. Its velocity at point A is 8.0 m/s and at point B is 5.0 m/s. Use the impulse-momentum theorem to find how long the sled takes to travel from A to B. (1.2s)

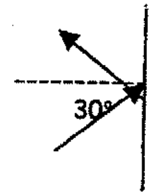
6. A 200g ball is dropped from a height of 2.0m, bounces on a hard floor, and rebounds to a height of 1.5 m. The graph shows the impulse received from the floor. What maximum force does the floor exert on the ball? (944 N)



7. It is well known that bullets and other missiles fired at Superman's chest simply bounce off his chest. Suppose that a gangster sprays Superman's chest with 3g bullets at the rate of 100 bullets per minute, the speed of each bullet being 500m/s. Suppose too that the bullets rebound straight back with no change in speed. What is the average force exerted by the stream of bullets on Superman's chest? (5 N)

8. A ball having a mass of 150g strikes a wall with a speed of 5.2m/s and rebounds with only 50 % of its initial kinetic energy. What is the speed of the ball immediately after rebounding? What is the magnitude of the impulse of the ball on the wall? If the ball was in contact with the wall for 7.6ms, what was the average force exerted by the wall on the ball? (-1.33 Ns, -175 N)

9. A 300g ball moving at speed 6m/s strikes a wall at an angle of 30° and then rebounds with the same speed and angle. It is in contact with the wall for 10ms. (a) What is the impulse on the ball? What is the average force exerted by the ball on the wall? (-3.12 Ns, 312 N)



10. Suppose a force, $F(t) = 6t^2 - 3t + 1$ acts on a 7-kg mass for three seconds. (a) What magnitude of impulse will the 7-kg object receive in the first three seconds? (b) If the mass started from rest, what is its final speed? (43.5 Ns, 6.21 m/s)

11. A 2500 kg unmanned space probe is moving in the positive y direction at a constant speed of 300m/s. Control rockets on the space probe execute a burn in which a thrust (force) of 3000N acts for 65s. What is the magnitude of the in final speed of the probe if the thrust is (a) backward, (b) forward or (c) directed sideways towards the positive x axis ? What is the change in kinetic energy under the same three conditions? Assume that the mass of the ejected fuel is negligible compared to the mass of the space probe. (378 m/s, 222 m/s, 309.9 m/s) (66,105,000J, -50,895,000J, 7,547,513J)

12. A spacecraft is separated into two parts by detonating the explosive bolts that hold them together. The masses of the parts are 1200 kg and 1800 kg; the magnitude of the impulse on each part is 300 Ns. With what relative speed do the two parts separate because of the detonation? (0.42 m/s)

W5H1 Momentum.

1.

Before: 0.1 kg ball → 50 m/s

After: 50 m/s ← 0.1 kg ball

Impulse = Force × time.
= changing of momentum.

$$\therefore \text{Impulse} = \Delta mv = mv_{final} - mv_{Before}$$

$$= 0.1 \times -50 - 0.1 \times 50$$

$$= -5 - 5 = -10 \ N \cdot s$$

↑ left direction.

$$\text{Impulse} = -10 = F \cdot (0.001)$$

$$\therefore F = -\frac{10}{0.001} = -10000 \ N.$$

↑ left direction.

U5H1 Momentum.

3. Impulse = Area of Force-time graph.

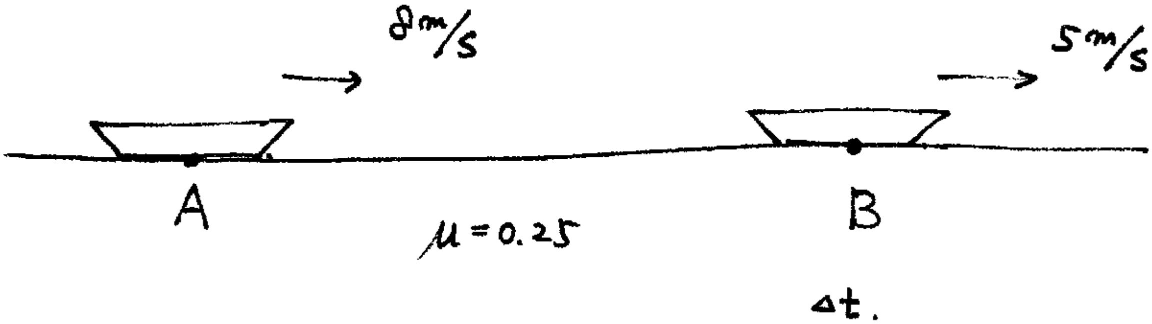
$$= -2 \times 500 \times 10^{-3} + \frac{1}{2} \times 6 \times 2000 \times 10^{-3}$$

= −1~~000~~ + 6~~000~~

= 5~~000~~ N·s

Momentum.

5.



$$\text{Impulse} = F \cdot \Delta t = \Delta m v$$

$$-\,\text{friction} \cdot \Delta t = m v_B - m v_A$$

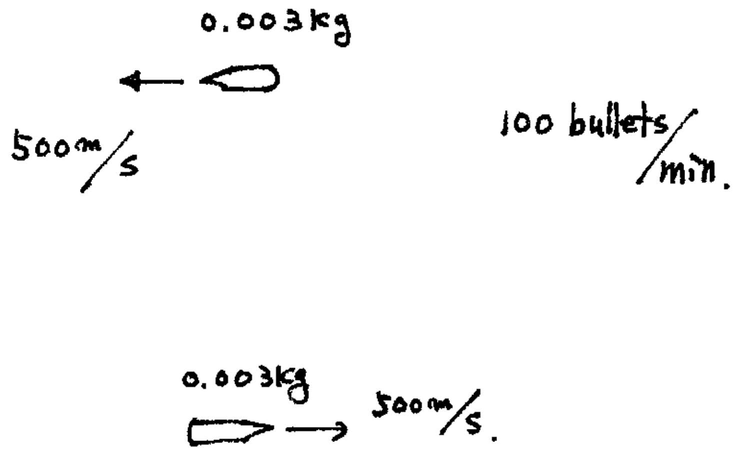
$$-\,0.25 \cdot N \cdot \Delta t = 5m - 8m$$

$$-\,0.25 \cdot m \cdot g \cdot \Delta t = -3m$$

$$\Delta t = \frac{3}{0.25 \cdot 10} = 1.2 \text{ sec}$$

U5H1. Momentum.

7.



$$\text{Impulse} = F \cdot \Delta t = \Delta m v$$

$$F \cdot \Delta t = 0.003 \times 500 - 0.003 \times (-500)$$

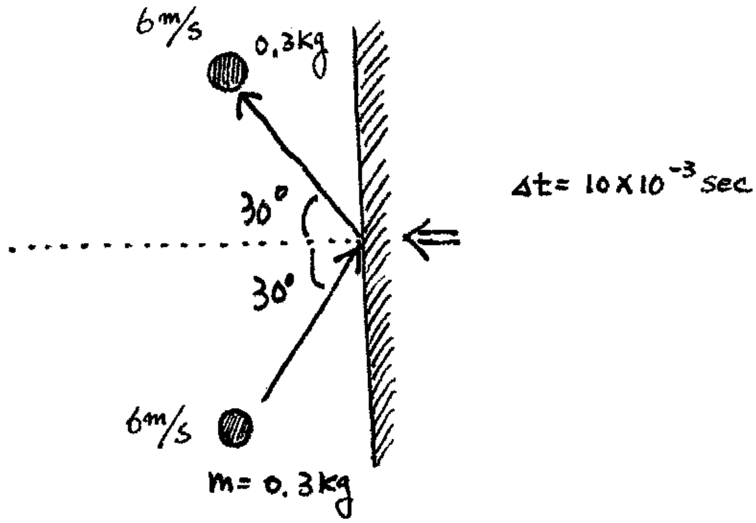
$$= 3.$$

$$\therefore \quad F = \frac{3}{\Delta t} = 3 \times \frac{100}{60} = 5\ N.$$

U5H1

Momentum.

9.



Before.

x- direction.

$0.3 \times 6 \times \cos 30°$

$= 1.56$

y- direction.

$0.3 \times 6 \times \sin 30°$

$= 0.9$

After

$-0.3 \times 6 \times \cos 30°$

$= -1.56$

$0.3 \times 6 \times \sin 30°$

$= 0.9.$

$\Delta mv = -3.12.$

$\Delta mv = 0.$

$\therefore \quad F \cdot \Delta t = -3.12. \text{ Ns}.$

$$F = \frac{-3.12}{10 \times 10^{-3}} = 312 \text{ N}$$

U5H1 Momentum.

11. $\Delta t = 65\,sec$

300 m/s

2500 kg

$K.E = \frac{1}{2} \cdot 2500 \cdot 300^2 = 112500000\,J$

$mv = 300 \times 2500 = 750000$

(a) F

$Impulse = 3000 \times 65 = 195000$

$\therefore \quad mv_f = 750000 + 195000$

$$v_f = \frac{750000 + 195000}{2500} = 378\ m/s.$$

$K.E = \frac{1}{2} \cdot 2500 \cdot 378^2 = 1.786 \times 10^8 \quad \Delta KE = 6.6 \times 10^7\,J$

(b). $$v_f = \frac{750000 - 195000}{2500} = 222\ m/s$$

$K.E. = \frac{1}{2} \cdot 2500 \cdot 222^2 = 6.16 \times 10^7\,J$

$\Delta KE. = 5.0895 \times 10^7\,J$

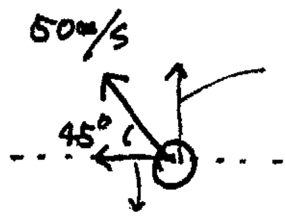
(c) $$v_{f_x} = \frac{195000}{2500} = 78\ m/s.$$

$\therefore \quad v = \sqrt{300^2 + 78^2} = 309.97\ m/s$

$K.E. = \frac{1}{2} \cdot 2500 \cdot 309.97^2 = 1.2 \times 10^8\,J.$

$\Delta KE. = 7.605 \times 10^6\,J.$

2.



$50 \times \sin 45° = \frac{50}{\sqrt{2}}$

~~y-dir~~

$0.1 \times \frac{50}{\sqrt{2}} = \frac{5}{\sqrt{2}}$

x-dir

$\frac{50}{\sqrt{2}}$ $\quad 0.1 \times -\frac{50}{\sqrt{2}}$

$\frac{-5}{\sqrt{2}}$

0.1kg

O → 50m/s. $\quad 0.1 \times 50 = 5$ (x-dir) $\quad \emptyset$ (y-dir)

$\Delta mv = mv - m_0 v_0$

x - direction.

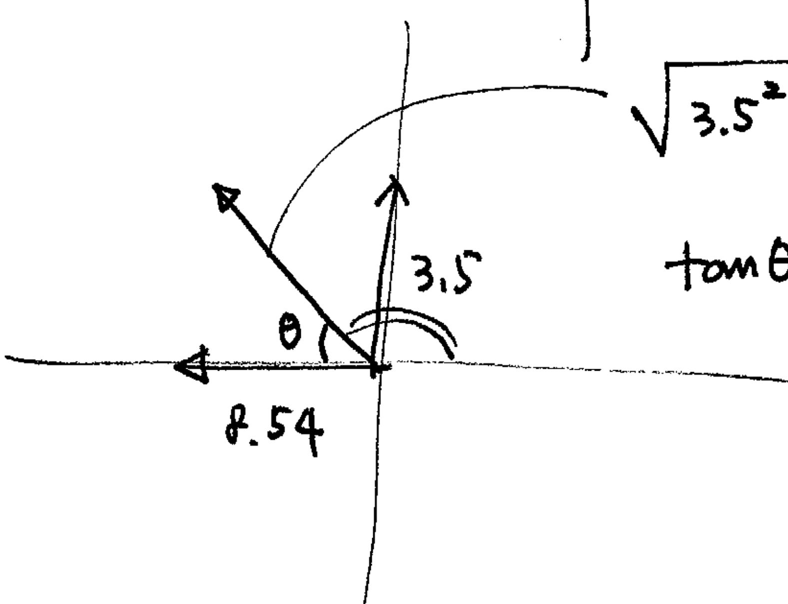
$\Delta mv = -\frac{5}{\sqrt{2}} - 5$

$= -8.54. = \text{Impulse}_x$

$= F \cdot \Delta t$

y-direction

$\Delta mv = 3.5 = \text{Impulse}_y$.

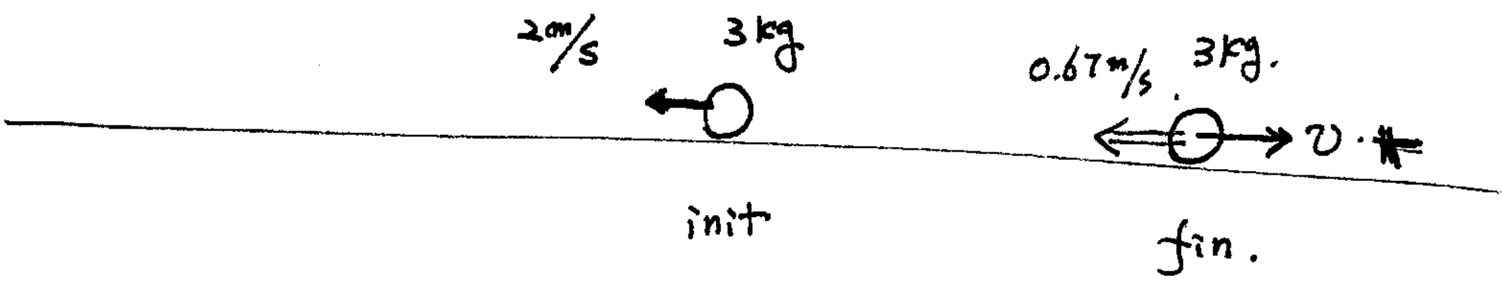


$\sqrt{3.5^2 + 8.54^2} = 9.19$ N·sec

$\tan\theta = \frac{3.5}{8.54}$, $\theta = 22.38°$

4.

$t=0.$ $t=6.$



$\Delta mv = 3\cdot v - (3\times -2) = 3v+6$

$= F\cdot\Delta t = \frac{1}{2}\times 4 \times 1000 \,(\times 10^{-3}) + 2\times 1000 \,(\times 10^{-3})$

$= \sout{4000}\ N\cdot s = 4\cdot N\cdot s.$

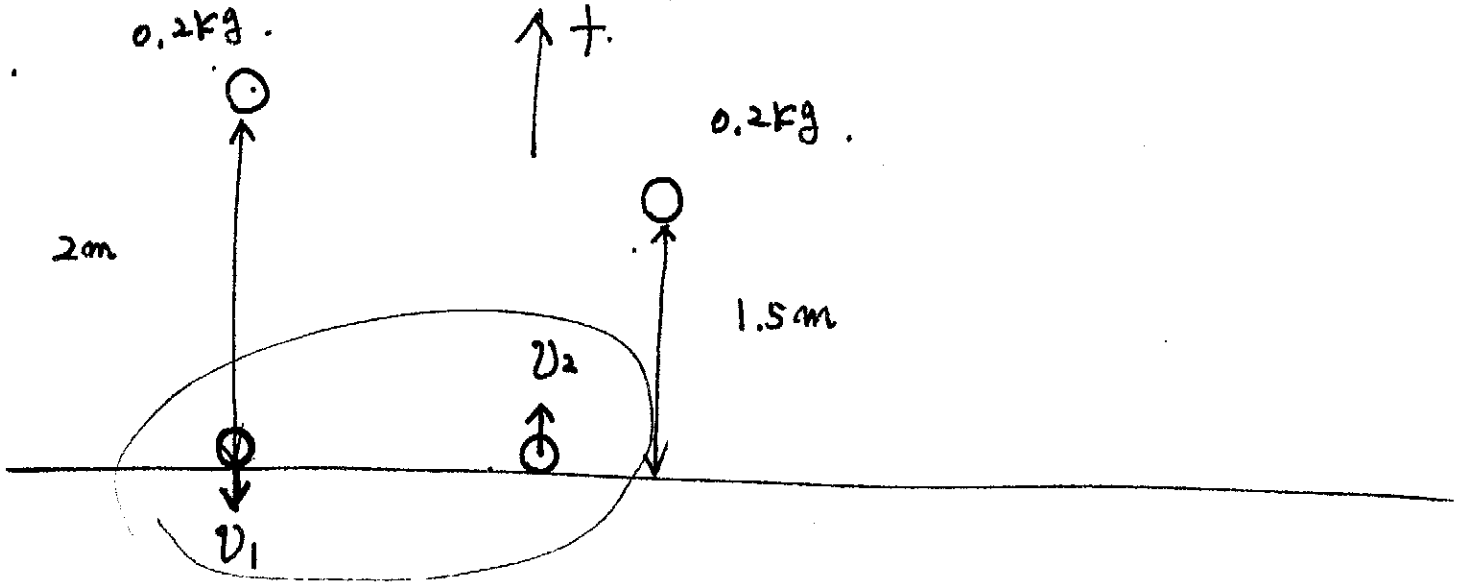
~~$3v+6 = 4000$~~

~~$v = \frac{3994}{3}$~~ $= 1331.34\ m/s.$

$3v+6 = 4.$

$v = -0.67\ m/s.$

6.



$$\Delta mv = 0.2 \cdot v_2 - 0.2(-v_1) = F \cdot \Delta t$$

*

$$0.2 \cdot 10 \cdot 2 = \frac{1}{2} \times 0.2 \times v_1^2$$

$$40 = v_1^2$$

$$v_1 = 6.32 \text{ m/s}$$

$$0.2 \times 10 \times 1.5 = \frac{1}{2} \times 0.2 \times v_2^2$$

$$30 = v_2^2$$

$$v_2 = 5.48 \text{ m/s}$$

$$\Delta mv = 0.2 \times 5.48 - 0.2 \times (-6.32)$$

$$= 2.36 = F \cdot \Delta t = \frac{1}{2} \times 5 \times 10^{-3} \times F_{max}$$

$$F_{max} = 2 \cdot 2.36 \times \frac{1}{5 \times 10^{-3}} = 944 N$$

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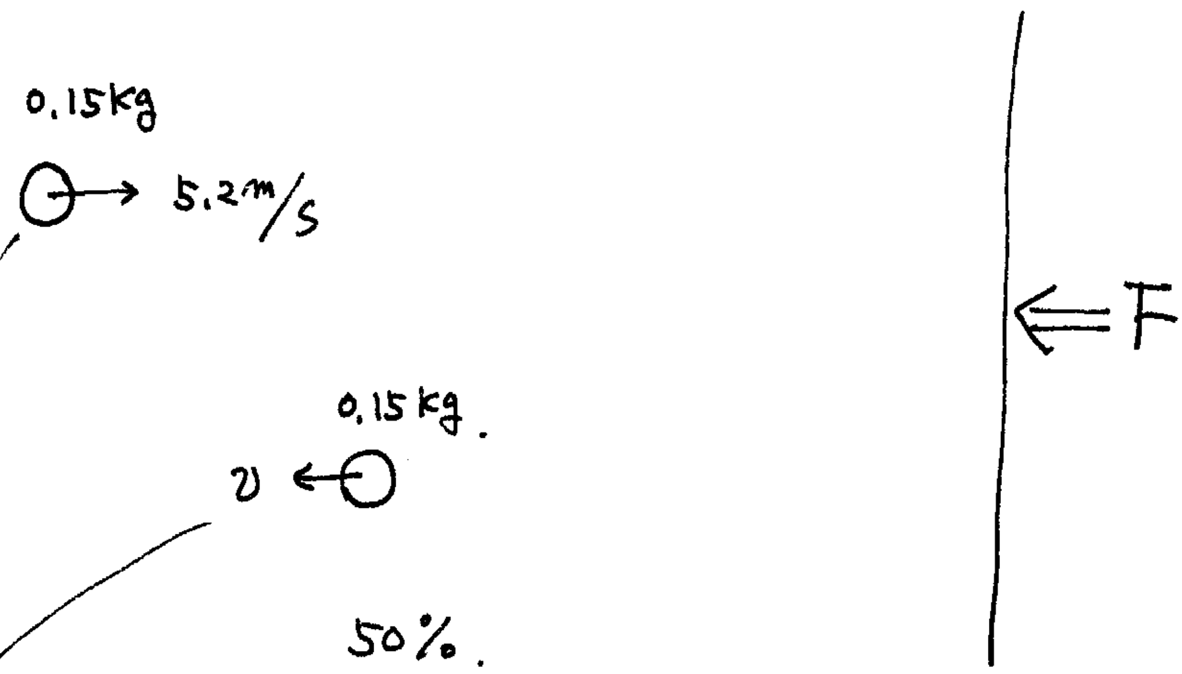


a.

$K.E. = \frac{1}{2} \times 0.15 \times 5.2^2 = 2.028\ J$

$K.E. = \frac{1}{2} \times 0.15 \times v^2 = 1.014 \longrightarrow v = 3.68\ m/s$

b. $\Delta mv = (0.15)(-3.68) - (0.15)(5.2) = \text{Impulse}$

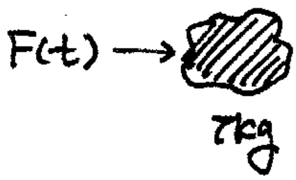
$-1.32\ Ns = \text{Impulse}$

$= F \cdot \Delta t$

$F = \frac{-1.332}{7.6 \times 10^{-3}} = -175\ N$

U5H1. Momentum.

10. $F(t) = 6t^2 - 3t + 1$ $\Delta t = 3$.



(a) $Impulse = \Delta mv = F \cdot \Delta t$

$\therefore Impulse = \int_0^3 (6t^2 - 3t + 1)\, dt$

$= \frac{87}{2}$ N·sec. (= 43.5 Ns)

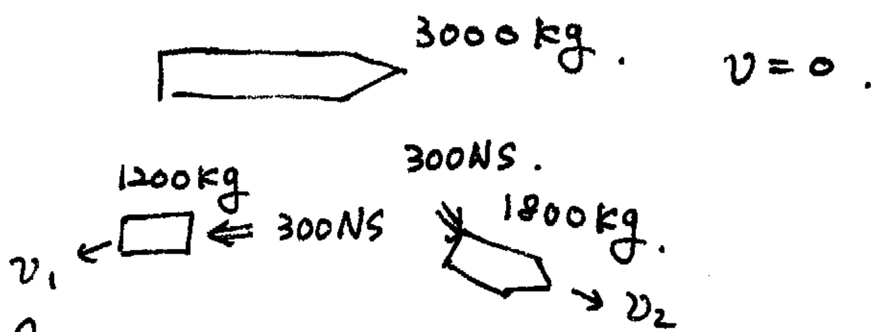
(b). $Impulse = \Delta mv = mv_2 - mv_1$

$43.5 = 7 \times v_2$

$\therefore v_2 = \frac{43.5}{7} = 6.21$ m/s

U5H1 Momentum.

12.



$\therefore$ Impulse = $\Delta m v$

$300 = 1200 \times v_1$

$\therefore v_1 = \frac{3}{12} = \frac{1}{4}$

$= 0.25$ m/s

$300 = 1800 \times v_2$

$v_2 = \frac{3}{18}$

$= \frac{1}{6}$

$= 0.167$ m/s.

$v_{rel} = 0.25 + 0.167 = 0.417$ m/s.