Wallace Hall Academy

CfE Higher Physics

Our Dynamic Universe

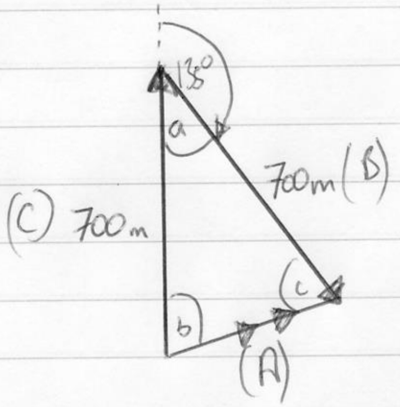
Exam Questions Part 1: Solutions

OUR DYNAMIC UNIVERSE : EXAM QUESTIONS PART 1

Vectors

1a) Vector – Magnitude and direction
Scalar – Magnitude only.

b)



Use cosine rule:

$$a^2 = b^2 + c^2 - 2bc\cos A.$$
$$= 700^2 + 700^2 - 2 \times 700 \times 700 \cos 45^\circ$$
$$= 287035.35$$
$$a = \underline{\underline{535.8\ m}}$$

$$\left[\begin{array}{l} a = 180 - 135 \\ \quad = 45^\circ \end{array}\right]$$

Angle of b = Angle of c since triangle is an isosceles.

$$\Rightarrow \quad \text{Angle } b = \frac{(180-45)}{2}$$
$$= 67.5^\circ$$

$\Rightarrow \quad s = \underline{535.8m}$ at bearing of $\underline{\underline{067.5^\circ}}$

b(ii) Andy's time, $t = \frac{d}{v}$

$$= \frac{(700 + 700)}{3}$$

$$= 466.66 \text{ s}$$

$\Rightarrow \quad \bar{v} = \frac{s}{t}$

$$= \frac{535.7}{466.66}$$

$$= \underline{\underline{1.15 \text{ m s}^{-1}}} \text{ at } \underline{\underline{067.5^\circ}}$$

(iii) $v = \underline{\underline{2.5 \text{ ms}^{-1}}}$ at $\underline{\underline{067.5^\circ}}$

(iv) Andy's journey time $= 466.66$ s.

Paul's time, (journey) $t = \frac{d}{v}$

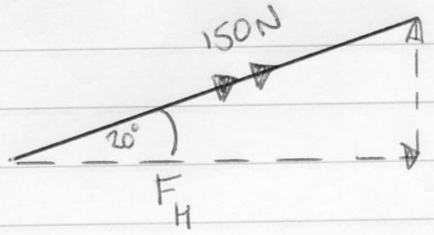
$$= \frac{535.7}{2.5}$$

$$= 214.28$$

Paul's total time $= 214.28 + (5 \times 60)$
$= 514.28$ s

$\Rightarrow$ Andy reaches control point $\underline{\underline{47.6 \text{ s}}}$ ahead of Paul.

2a)

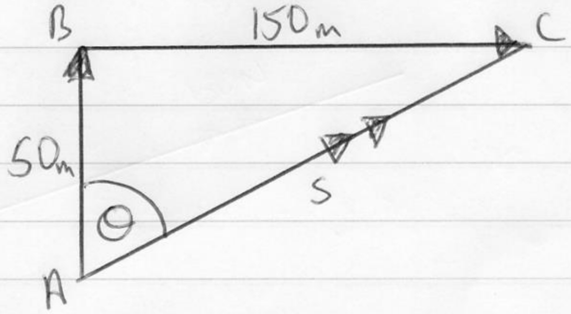


$$F_H = 150\cos 20^\circ$$
$$= 140.95$$
$$= 141\ N$$

$\Rightarrow$ Total force in direction of travel

$$F_{TOT} = 141 \times 2$$
$$= \underline{\underline{282\ N}}$$

b) Magnitude of frictional force $= \underline{\underline{282\ N}}$.
(as boat moving at constant speed)

3a) 

$$AC^2 = AB^2 + BC^2$$
$$s^2 = 50^2 + 150^2$$
$$= 25000$$
$$s = \sqrt{25000}$$
$$= 158.11$$
$$= \underline{\underline{158\,m}}$$

$$\tan\theta = \frac{Opp}{Adj}$$

$$\theta = \tan^{-1}\frac{Opp}{Adj}$$

$$= \tan^{-1}\frac{150}{50}$$
$$= 71.6^\circ$$

$$\Rightarrow \quad s = \underline{\underline{158\,m \quad at\ 071.6^\circ}}$$

bi) $d = 50 + 150 + 158$
$= \underline{\underline{358\,m}}$

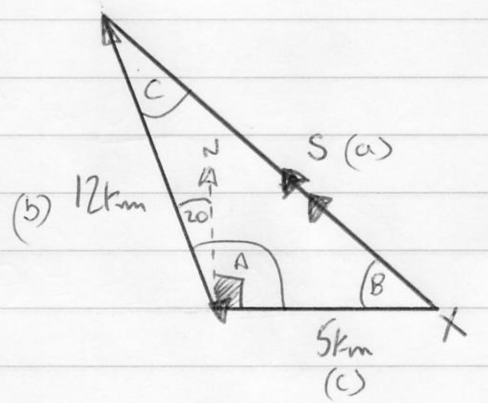
(ii) $s = \underline{\underline{0}}\ m$

4a) Speed - Scalar (magnitude only)
Velocity - Vector (magnitude and direction)

b) (i)

$$\text{Distance} = d_{leg1} + d_{leg2}$$
$$= (10 \times 0.5) + (8 \times 1.5)$$
$$= 5 + 12$$
$$= \underline{\underline{17\,\text{Km}}}$$

(ii)



$$s^2 = b^2 + c^2 - 2bc\cos A$$
$$= 12^2 + 5^2 - 2 \times 12 \times 5 \times \cos 110^\circ$$
$$= 210.04$$
$$\Rightarrow s = \sqrt{210.04}$$
$$= \underline{\underline{14.5}}\ \text{Km}$$

$$\frac{\sin 110}{14.5} = \frac{\sin B}{12}$$

$$\sin B = \frac{12 \sin 110}{14.5} = 0.7776$$

$$\Rightarrow B = 51^\circ$$
$$\Rightarrow s = \underline{14.5\ \text{Km}} \text{ at } \underline{321^\circ}$$

4 bii) $\bar{v} = \frac{s}{t}$

$= \frac{14.5}{2}$

$= \underline{\underline{7.25\ \text{km h}^{-1}}}$ at $\underline{\underline{321}}$

c) Leeuvin's journey time, $t = \frac{s}{v}$

$= \frac{14.5}{7.5}$

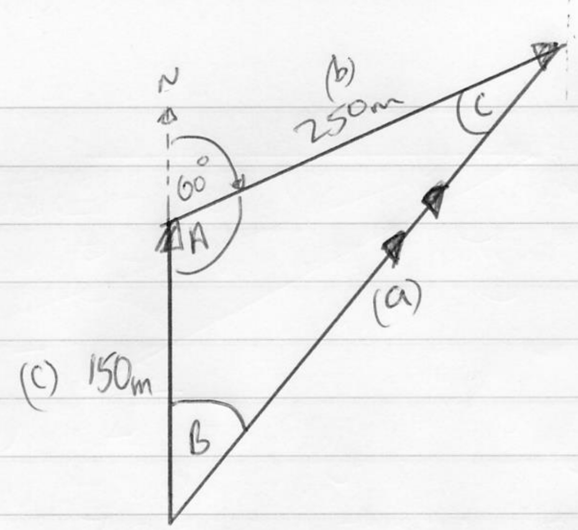
$= 1.93$ hours

Leeuvin's Total time $= 1.93 + 0.25$

$= \underline{\underline{2.18}}$ hours

$\Rightarrow$ Mir arrives first at bouy Y by $\underline{\underline{0.18 \text{ hours}}}$.

5 a)



$$a^2 = b^2 + c^2 - 2bc\,\mathrm{Cos}\,A$$
$$= 250^2 + 150^2 - 2 \times 250 \times 150 \times \mathrm{Cos}\,120^\circ$$
$$= 122500$$
$$a = \sqrt{122500}$$
$$= \underline{\underline{350\ m}}$$

$$\frac{\mathrm{Sin}\,A}{a} = \frac{\mathrm{Sin}\,B}{b}$$

$$\frac{\mathrm{Sin}\,120}{350} = \frac{\mathrm{Sin}\,B}{250}$$

$$\mathrm{Sin}\,B = \frac{\mathrm{Sin}\,120 \times 250}{350}$$

$$= 0.618$$
$$B = \mathrm{Sin}^{-1}\,0.618$$
$$= 38^\circ$$

$$\Rightarrow\ s = \underline{\underline{350m}}\ \text{at}\ \underline{\underline{038^\circ}}$$

5 b) $v = \frac{s}{t}$

$= \frac{350}{66}$

$= \underline{5.3\ ms^{-1}}$ at $\underline{038^\circ}$

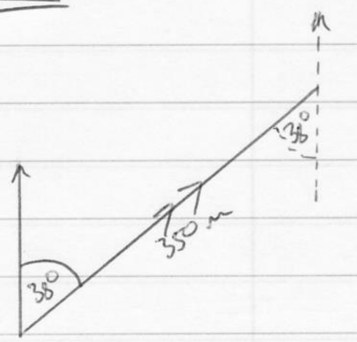
c) $t_y = \frac{s}{v}$

$= \frac{400}{6.5}$

$= \underline{61.5\ s}$

$\Rightarrow$ Car y arrives first by $\underline{4.5\ s}$

d) $s = \underline{350\ m}$ at $\underline{218^\circ}$



Equations of Motions

1a) $s = ut + \frac{1}{2}at^2$

$20 = 0 + \frac{1}{2} \times 1.6 \times t^2$

$20 = 0.8t^2$

$t^2 = \frac{20}{0.8}$

$t = \sqrt{\frac{20}{0.8}}$

$= 5s$

$s = 20$
$u = 0$
$v = x$
$a = 1.6$
$t = ?$

Both sprinters take 5s.

b) $V_p = u + at$

$= 0 + 1.6 \times 5$

$V_p = 8 ms^{-1}$

$s = 20$
$u = 0$
$v = ?$
$a = 1.6$
$t = 5$

$V_Q = u + at$

$= 0 + 1.2 \times 5$

$V_Q = 6 ms^{-1}$

$s = 20$
$u = 0$
$v = ?$
$a = 1.2$
$t = 5$

c) $S_Q = ut + \frac{1}{2}at^2$

$= 0 + \frac{1}{2} \times 1.2 \times 5^2$

$= 15m$

$s = ?$
$u = 0$
$v = 6$
$a = 1.2$
$t = 5$

$\Rightarrow$ Difference $= 20 - 15 = 5m$

2a)

$$V = at$$

square both sides

$$v^2 = a^2 t^2 \quad (1)$$

$$s = \frac{1}{2} a t^2$$

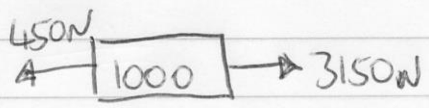
$$\Rightarrow t^2 = \frac{2s}{a} \quad (2)$$

Substitute (2) into (1):

$$v^2 = a^2 t^2$$
$$v^2 = a^2 \left(\frac{2s}{a}\right)$$

$$\Rightarrow \underline{\underline{v^2 = 2as}}$$

b i)



$$\Rightarrow F_{un} = ma$$

$$3150 - 450 = 1000\,a$$

$$a = \frac{2700}{1000} = \underline{\underline{2.7 \text{ m s}^{-2}}}$$

2bii) $v^2 = u^2 + 2as$

$33^2 = 0 + 2 \times 2.7 \times s$

$1089 = 5.4s$

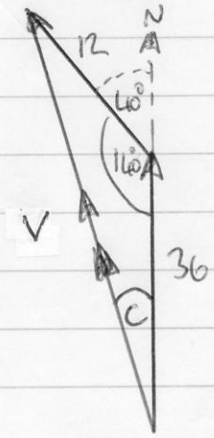
$s = \dfrac{1089}{5.4}$

$= 201.66$

$= \underline{\underline{202\,m}}$

$s = ?$
$u = 0$
$v = 33$
$a = 2.7$
$t = \times$

c)



$V^2 = b^2 + c^2 - 2bc\cos A$

$= 12^2 + 36^2 - 2 \times 12 \times 36 \times \cos 140$

$= 2101.9$

$V = \sqrt{2101.9}$

$= 45.8\ ms^{-1}$

$\dfrac{\sin C}{c} = \dfrac{\sin A}{A}$

$\dfrac{\sin C}{12} = \dfrac{\sin 140}{45.8}$

$\sin C = \dfrac{12 \sin 140}{45.8} = 0.168$

$C = \sin^{-1} 0.168$

$= 9.7°$

$\Rightarrow$ $v = \underline{\underline{45.8\ ms^{-1}}}$ at $\underline{\underline{350°}}$

11

3a) $s = ut + \frac{1}{2}at^2$
$= 0 + \frac{1}{2} \times 4 \times 7^2$
$= \underline{\underline{98m}}$

$s = ?$
$u = 0$
$v =$
$a = 4$
$t = 7$

(ii) $V_1 = u + at$
$= 0 + 4 \times 7$
$= 28ms^{-1}$

$s = 98$
$u = 0$
$v = ?$
$a = 4$
$t = 7$

$V_2^2 = u^2 + 2as$
$= 0 + 2 \times 4 \times 196$
$= 1568$
$V_2 = \sqrt{1568}$
$= 39.6\ ms^{-1}$

$s = 196m$
$u = 0$
$v = ?$
$a = 4$
$t = ?$

$\Rightarrow$ Increase in speed $= 39.6 - 28$
$= \underline{\underline{11.6\ ms^{-1}}}$

(iii) $v^2 = u^2 + 2as$
$0 = 40^2 + 2 \times (-2.5) \times s$
$0 = 1600 - 5s$
$5s = 1600$
$s = \frac{1600}{5}$
$= \underline{\underline{320m}}$

$s = ?$
$u = 40$
$v = 0$
$a = -2.5$
$t = \times$

3b) (i) The student must measure:

- Length of interupt card/mask (d)
- Time taken for trolley to travel from light gate 1 to light gate 2 using stop watch. (t_3)

The computer will measure:

- The time card cuts light beam at top light gate. (t_1)
- The time card cuts light beam at bottom light gate. (t_2)

(ii) Initial speed (u) at top of slope calculated using $u = \frac{d}{t_1}$

final speed (v) at bottom of slope calculated using $v = \frac{d}{t_2}$

accelation (a) calculated using

$$a = \frac{(v - u)}{t_3}$$

Force, Energy and Power

1a i)

$F_H = 4.0 \cos 26°$
$= 3.5951$
$= \underline{\underline{3.6\,N}}$

(ii) $F = ma$
$3.6 = 18a$
$a = \frac{3.6}{18}$
$= \underline{\underline{0.2\,ms^{-2}}}$

(iii) $s = ut + \frac{1}{2}at^2$
$= 0 + \frac{1}{2} \times 0.2 \times 7.0^2$
$= \underline{\underline{4.9\,m}}$

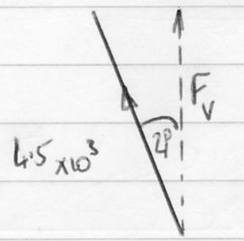
$s = ?$
$u = 0$
$v = \times$
$a = 0.2$
$t = 7s.$

b) Horizontal component of force will increase as angle decreases

$\Rightarrow$ acceleration will increase as $a = \frac{F_H}{m}$

$\Rightarrow$ distance will increase.

2a i)



$$F_v = 4.5\times10^3 \cos 21$$
$$= 4201\ N$$
$$= \underline{\underline{4.2\times10^3\ N}}$$

(ii) Total upwards force $= 4.2\times10^3 \times 2$
$$= 8.4\times10^3\ N$$

$$F_{un} = ma$$

$$8.4\times10^3 - (236\times9.8) = 236\times a$$
$$a = \frac{6087.2}{236}$$

$$a = 25.79$$
$$= \underline{\underline{26\ ms^{-2}}}$$

(iii) As capsule rises, tension in ropes decreases.
$\Rightarrow$ Unbalanced force on capsule decreases.

b) Both the people and seats/capsule are accelerating towards the ground at $\underline{\underline{9.8\ ms^{-2}}}$.

3a) $W = mg\sin\theta$

$= 2600 \times 9.8 \times \sin 12$

$= 5330$

$= \underline{\underline{5.3 \times 10^3 \text{ N}}}$

b) $F_{un} = ma$

$5.3\times10^3 - 1400 = 2600 \times a$

$a = \dfrac{3900}{2600}$

$= \underline{\underline{1.5 \text{ ms}^{-2}}}$

c) $v^2 = u^2 + 2as$

$v^2 = 5.0^2 + 2\times1.5\times75$

$= 250$

$v = \sqrt{250}$

$= 15.8 \text{ ms}^{-1}$

$s = 75$

$u = 5.0$

$v = ?$

$a = 1.5$

$t = \times$

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

$= \frac{1}{2} \times 2600 \times 15.8^2$

$= \underline{\underline{3.25 \times 10^5 \text{ J}}}$

4a) $W_p = mg\sin\theta$

$= (52+8) \times 9.8 \times \sin 22^\circ$

$= 220.26$

$= \underline{\underline{220\ N}}$

b) $F_{un} = ma$

$220 - 180 = 60 \times a$

$a = \frac{40}{60}$

$= \underline{\underline{0.67\ ms^{-2}}}$

c) $v^2 = u^2 + 2as$ $\quad s = 50$

$= 0 + 2 \times 0.67 \times 50$ $\quad u = 0$

$= 67$ $\quad v = ?$

$v = \sqrt{67}$ $\quad a = 0.67$

$= \underline{\underline{8.2\ ms^{-1}}}$ $\quad t =$

d) Smaller mass means smaller component of weight.

$\Rightarrow$ Smaller unbalanced force down slope.

$\Rightarrow$ Smaller acceleration down slope

$\Rightarrow$ smaller speed at bottom of slope.

5a) $v^2 = u^2 + 2as$ $\quad$ $s = ?$

$12^2 = 30^2 + 2 \times (-9) \times s$ $\quad$ $u = 30$

$144 = 900 - 18s$ $\quad$ $v = 12$

$18s = 900 - 144$ $\quad$ $a = -9.0$

$s = \frac{(900 - 144)}{18}$ $\quad$ $t =$

$= \underline{\underline{42\,m}}$

b) Since mass is greater, deceleration is less since

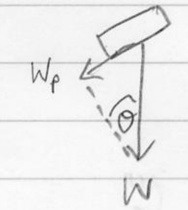
$$a = \frac{F}{m}. \quad \text{and } F \text{ constant.}$$

$\Rightarrow$ speed is greater at Q for second test.

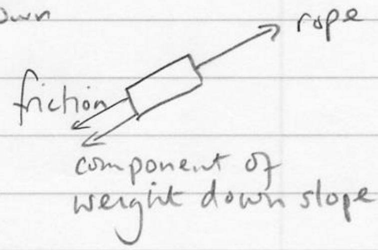
6ai) $W_p = mg\sin\theta$

$= 40 \times 9.8 \times \sin 30$

$= \underline{\underline{196\,N}}$



(ii) Constant speed so $F_{up} = F_{down}$



$\Rightarrow \quad 240 = 196 + F_f$

$F_f = 240 - 196$

$= \underline{\underline{44\,N}}$

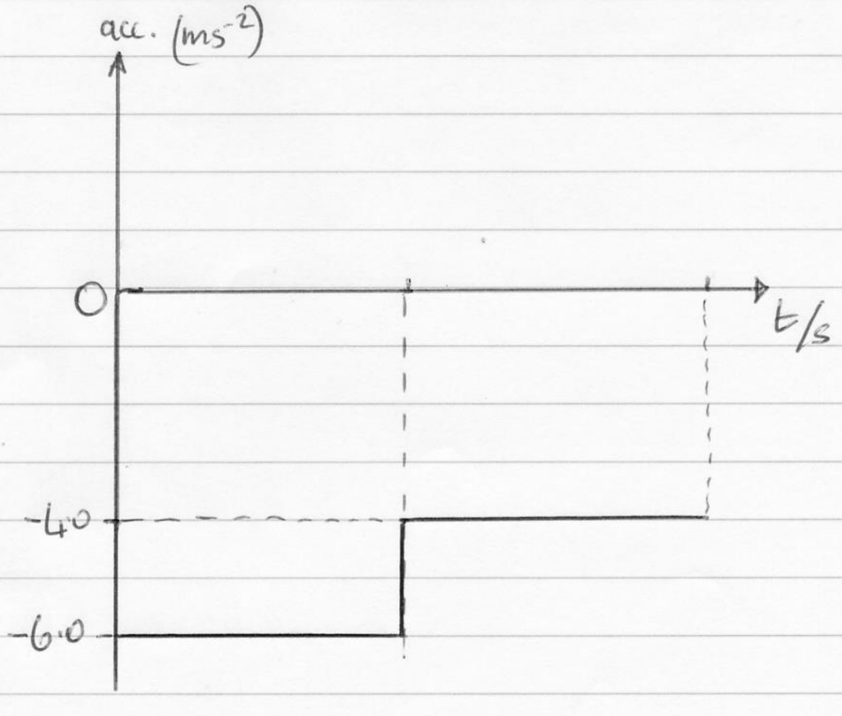
b i) There is a constant negative acceleration

of $a = \dfrac{v-u}{t}$

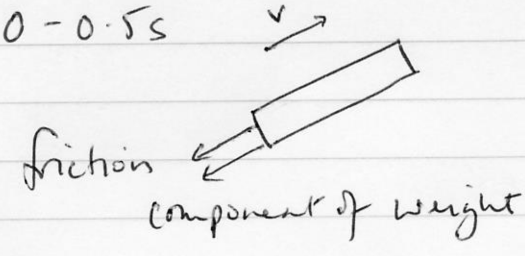
$= \dfrac{0-3}{0.5}$

$= \underline{\underline{-6\,ms^{-2}}}$

(ii)

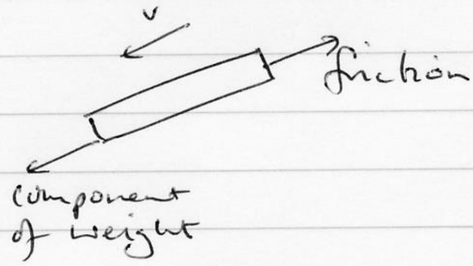


6. (b) (iii) 0 – 0·5 s



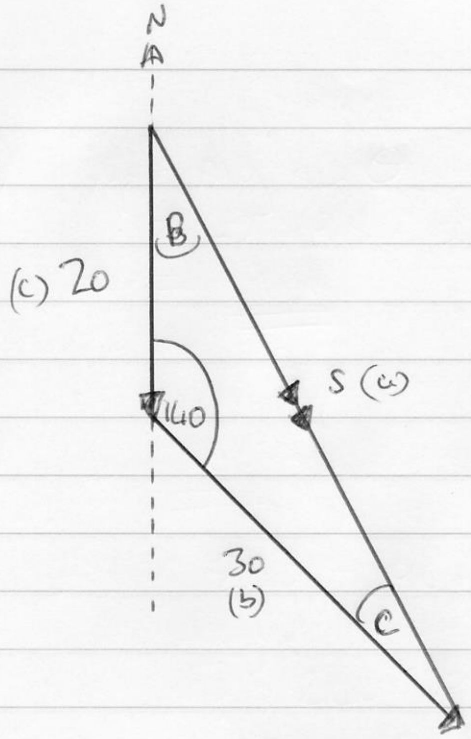
Force of friction adds to the component of the weight acting down the slope giving a large unbalanced force and resulting acceleration.

0·5 – 1·0 s



Force of friction is now in the opposite direction to the component of weight down the slope giving a smaller unbalanced force and resulting acceleration.

7(ai)



$$s^2 = b^2 + c^2 - 2bc \cos A$$
$$= 20^2 + 30^2 - 2 \times 20 \times 30 \times \cos 140^\circ$$
$$= 2219$$
$$S = \underline{\underline{47.1 \text{ Km}}}$$

$$\frac{\sin B}{b} = \frac{\sin A}{a}$$

$$\frac{\sin B}{30} = \frac{\sin 140}{47.1}$$

$$\sin B = \frac{\sin 140 \times 30}{47.1}$$

$$= 0.409$$

$$B = \sin^{-1} 0.409$$
$$= 24.16$$
$$= \underline{\underline{24^\circ}}$$

$$S = \underline{\underline{47.1 \text{ Km}}} \text{ at } \underline{\underline{156^\circ}}$$

7a ii) $\bar{v} = \frac{s}{t}$

$= \frac{47.1 \times 10^3}{15 \times 60}$

$= 52.3 \text{ ms}^{-1}$ at 156

b i) For constant height, Lift = weight

Lift $= mg$

$= 1.21 \times 10^4 \times 9.8$

$= 118580$

$= 119 \text{ kN}$

(ii) As crate is dropped, the mass of helicopter decreases, so it's weight decreases. As lift is constant, the unbalanced force acts upwards so helicopter accelerates upwards.

8 a) $t = 3.6\,s$

This is the time the velocity is zero, indicating a change in velocity from negative (downwards) to positive (upwards).

b) Calculate av. acceleration

$s = $
$u = -18\,ms^{-1}$
$v = 16\,ms^{-1}$
$a = ?$
$t = 3\,s$

$$a = \frac{v-u}{t}$$
$$= \frac{16-(-18)}{3}$$
$$= \frac{34}{3}$$
$$= 11.3\,ms^{-2}$$

$$F_{un} = ma$$
$$= 55 \times 11.3$$
$$= 621.5$$
$$= 622\,N$$

c) An elastic rope stretches which increases the time over which the change in velocity occurs. This reduces the average force acting on the person reducing the chance of injury.

[Since $F_{un} = \frac{mv - mu}{t}$]

Collisions and Explosions

1a)(i) $v^2 = u^2 + 2as$

$= 0 + 2 \times -9.8 \times -2.0$

$= 39.2$

$v = \sqrt{39.2}$

$= \underline{\underline{6.26 \text{ ms}^{-1}}}$

$s = -2.0 \text{ m}$

$u = 0$

$v = ?$

$a = -9.8 \text{ ms}^{-2}$

$t = \times$

or

$E_p = E_k$

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

$v^2 = 2gh$

$= 2 \times 9.8 \times 2.0$

$= 39.2$

$v = \sqrt{39.2}$

$= \underline{\underline{6.26 \text{ ms}^{-1}}}$

(ii) $F = \dfrac{mv - mu}{t}$

$= \dfrac{(15 \times 0) - (15 \times -6.26)}{0.02}$

$= \dfrac{93.9}{0.02}$

$= 4695 \text{ N}$

This is the force acting on the mass to decelerate it.

$\Rightarrow$ Force acting on pipe is equal but opposite

$\Rightarrow F_{pipe} = \underline{\underline{-4695 \text{ N}}}$

1b) The time over which the change in momentum $(mv - mu)$ will increase with the softer material so the average force will decrease as $F = \frac{(mv - mu)}{t}$ and $(mv - mu)$ is unchanged.

c) Mass X will cause more damage.

The change in momentum is the same, as is the time of contact, so the average force for both is the same.
However, the mass X has a smaller contact area due to it having a point so more pressure will be applied to the pipe causing more damage.

since $P = \frac{F}{A}$.

2a) Change in momentum $= mv - mu$

$$= (38 \times 4.6) - (38 \times 2.2)$$

$$= \underline{\underline{91.2 \text{ kg ms}^{-1}}}$$

b) $Ft = \Delta p$

$$130 \times t = 91.2$$

$$t = \frac{91.2}{130}$$

$$= \underline{\underline{0.70 \text{ s}}}$$

c) Total momentum before = Total momentum after

$$\overset{2.2 \rightarrow}{\boxed{(54+38)}} \quad \Longrightarrow \quad \overset{V_R}{\boxed{54}} \qquad \overset{4.6 \rightarrow}{\boxed{38}}$$

$$M_A u_A = M_B V_B + M_C V_C$$

$$(92 \times 2.2) = 54 V_R + (38 \times 4.6)$$

$$202.4 = 54 V_R + 174.8$$

$$54 V_R = 202.4 - 174.8$$

$$= 27.6$$

$$V_R = \frac{27.6}{54}$$

$V_R = \underline{\underline{0.51 \text{ ms}^{-1}}}$ (to the right).

2d) Total E_k before $= \frac{1}{2} m u^2$

$$= \frac{1}{2} \times (54 + 38) \times 2.2^2$$

$$= \underline{222.64\ J}$$

Total E_k after $= \frac{1}{2} m v_R^2 + \frac{1}{2} m v_s^2$

$$= \left(\frac{1}{2} \times 54 \times 0.51^2\right) + \left(\frac{1}{2} \times 38 \times 4.6^2\right)$$

$$= 7.0227 + 402.04$$

$$= \underline{409.0627\ J}$$

$\Rightarrow$ Since E_k before does not equal total E_k after then collision is <u>not elastic.</u>

3a) Total momentum before = Total momentum after.

$$M_a U_a + M_b U_b = M_T V$$

$$(2500 \times 0.50) + (1500 \times U_b) = (4000 \times 0.20)$$

$$1250 + 1500 U_b = 800$$

$$1500 U_b = 800 - 1250$$

$$= -450$$

$$U_b = \frac{-450}{1500}$$

$$U_b = \underline{\underline{-0.3 \, m \, s^{-1}}}$$

b) (i) The thrust from engine must act in opposite direction to that of the motion

$\Rightarrow$ <u>Probe's</u> engine was switched on.

(ii)

$$F = \frac{mv - mu}{t}$$

$$-500 = \frac{(4000 \times 0) - (4000 \times 0.20)}{t}$$

$$t = \frac{0 - 800}{-500}$$

$$= \underline{\underline{1.6 \, s}}$$

3c) Initial acceleration to the right hand side is achieved by firing the space vehicle's rocket engine. To decelerate it to rest at position B, the space probe's rocket engine must be fired. As it only produces half the thrust, the probe's engine must be fired for twice the time of the space vehicle's engine.

4a i) Impulse = Area under F/t graph

$$= \left(\tfrac{1}{2} \times 8\times10^{-3} \times 70\right) + \left(\tfrac{1}{2} \times 2\times10^{-3} \times 70\right)$$

$$= \underline{\underline{0{\cdot}35\ Ns}}$$

(ii) $\Delta p = \underline{\underline{0{\cdot}35\ Kg\ ms^{-1}}}$ $\underline{\underline{\text{upwards}}}$

(iii) Impulse $= mv - mu$

$$0{\cdot}35 = (0{\cdot}050 \times v) - (0{\cdot}050 \times (-5{\cdot}6))$$

$$0{\cdot}35 = 0{\cdot}050v + 0{\cdot}28$$

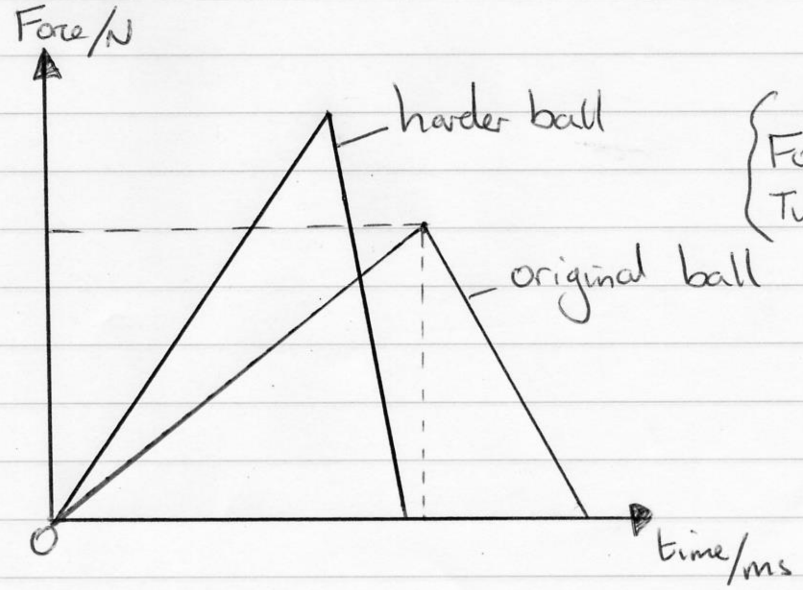
$$0{\cdot}050v = 0{\cdot}35 - 0{\cdot}28$$

$$= 0{\cdot}07$$

$$v = \frac{0{\cdot}07}{0{\cdot}050}$$

$$v = \underline{\underline{1{\cdot}4\ ms^{-1}}}$$

b)



Force greater (1)
Time less (1)

5 ai) Impulse = area under F/t graph

$= \frac{1}{2} \times 0.25 \times 6.4$

$= \underline{\underline{0.8 \text{ Ns}}}$

(ii) $\underline{\underline{0.8 \text{ kg ms}^{-1}}}$ to the left.

(iii) Impulse = change in momentum

$Ft = mv - mu$

$-0.8 = m(v - u)$

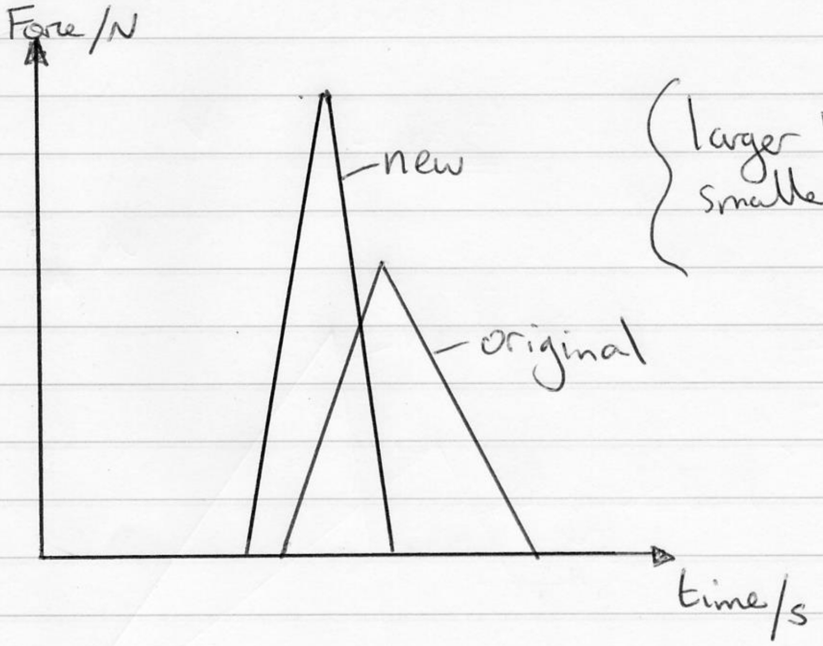
$-0.8 = m((-0.45) - 0.48)$

$-0.8 = -0.93m$

$m = \frac{-0.8}{-0.93}$

$m = \underline{\underline{0.86 \text{ kg}}}$

b)



{larger height (1)
smaller base (1)}

6a) Total momentum before a collision is equal to the total momentum after the collision in the absence of net external forces.

b i) Change in momentum = $mv - mu$

For vehicle A, $\Delta P = (0.75 \times 0.40) - (0.75 \times 0.82)$
$= -0.315 \text{ kg ms}^{-1}$

For vehicle B, $\Delta P = (0.50 \times 0.63) - (0.50 \times 0)$
$= 0.315 \text{ kg ms}^{-1}$

$\Rightarrow$ ΔP for A is equal but opposite to vehicle B.

(ii) Total E_k before $= E_k(A) + E_k(B)$
$= \frac{1}{2}mu^2 + \frac{1}{2}mu^2$
$= (\frac{1}{2} \times 0.75 \times 0.82^2) + (\frac{1}{2} \times 0.50 \times 0^2)$
$= \underline{\underline{0.252}}$ J.

Total E_k after $= E_k(A) + E_k(B)$
$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2$
$= (\frac{1}{2} \times 0.75 \times 0.40^2) + (\frac{1}{2} \times 0.50 \times 0.63^2)$
$= 0.06 + 0.099$
$= \underline{\underline{0.159}}$ J

Since E_k before does not equal E_k after the collision is <u>inelastic</u>.

7a) (i) Gain in E_p = loss in E_k

$$mgh = \frac{1}{2}mv^2$$
$$10 \times 9.8 \times 0.10 = \frac{1}{2} \times 10 \times v^2$$
$$v^2 = \frac{10 \times 9.8 \times 0.10}{\left(\frac{1}{2} \times 10\right)}$$
$$= \frac{9.8}{5}$$
$$= 1.96$$
$$v = \sqrt{1.96}$$
$$= \underline{\underline{1.4\ ms^{-1}}}$$

(ii) Total momentum before = total momentum after

$$\overset{u}{\boxed{0.025}} + \overset{0}{\boxed{M_{Box}}} \Rightarrow \overset{1.4 \rightarrow}{\boxed{10}}$$

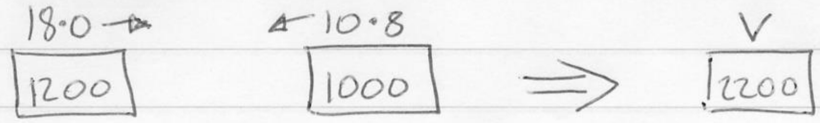
$$M_B u_B + M_{Box} u_{Box} = M_{TOT} V$$

$$(0.025 \times u) + 0 = (10 \times 1.4)$$
$$0.025u = 14$$
$$u = \frac{14}{0.025}$$

$$u = \underline{\underline{560\ ms^{-1}}}$$

b) The change in momentum of bullet will be greater so the change of momentum of box will be greater to ensure conservation of momentum. For the box to increase the change in momentum, it must move with a greater velocity initially. Therefore it has greater initial kinetic energy which will be transfered to potential energy resulting in a <u>greater</u> <u>height</u>.

8a) Total momentum before = Total momentum after



$$m_A u_A + m_B u_B = m_{(A+B)} V$$

$$(1200 \times 18{\cdot}0) + (1000 \times (-10{\cdot}8)) = 2200V$$

$$21600 - 10800 = 2200V$$

$$2200V = 10800$$

$$V = \frac{10800}{2200}$$

$$V = \underline{\underline{4{\cdot}91\ ms^{-1}}} \text{ (to the right)}$$

b ii) Total E_k before $= \frac{1}{2}mu_A^2 + \frac{1}{2}mu_B^2$

$$= \left(\tfrac{1}{2} \times 1200 \times 18{\cdot}0^2\right) + \left(\tfrac{1}{2} \times 1000 \times 10{\cdot}8^2\right)$$

$$= 194400 + 58320$$

$$= \underline{\underline{252720}}\ J.$$

Total E_k after $= \frac{1}{2}mv^2$

$$= \tfrac{1}{2} \times 2200 \times 4{\cdot}91^2$$

$$= \underline{\underline{26518{\cdot}91}}\ J.$$

Total E_k before does not equal Total E_k after so collision is <u>inelastic</u>.

bi) $$F = \frac{mv - mu}{t}$$

$$= \frac{(5 \times 0) - (5 \times 20)}{0.020}$$

$$= -5000$$

$$= -5.0\,kN$$

(ii) The airbag increases the time of contact and increases the time over which the change in momentum occurs. This means the average force is less as $F = \frac{(mv - mu)}{t}$.

Less average force means risk to damage is less.