MEI MECHANICS 2 IMPULSE EXERCISE 6A

1;) $50\text{ kg} \times 10\text{ ms}^{-1} = 500\text{ kgms}^{-1}$

ii) $5000\text{ kg} \times 4\text{ ms}^{-1} = 20000\text{ kgms}^{-1}$

iii) $7000 \times 10^{3}\text{ kg} \times 40\text{ ms}^{-1} = 2.8 \times 10^{8}\text{ kgms}^{-1}$

iv) $2 \times 10^{-19}\text{ kg} \times 1 \times 10^{-3}\text{ ms}^{-1} = 2 \times 10^{-22}\text{ kgms}^{-1}$

2)

i) Impulse = change in momentum

$1.3 \times 10^{3}\text{ kg} \times 14\text{ ms}^{-1} = 18200\text{ Ns}$

ii) $1.5 \times 10^{-3}\text{ kg} \times 1.5\text{ ms}^{-1} = 2.25 \times 10^{-3}\text{ Ns}$

iii) $0.15\text{ kg} \times 20\text{ ms}^{-1} = 3\text{ Ns}$

iv) $25 \times 10^{-3}\text{ kg} \times 400\text{ ms}^{-1} = 10\text{ Ns}$

3)

i) $F = mg = 1.5 \times 10 = 15\text{ N}$

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

$s = 0 + \frac{1}{2} \times 10 \times 2^2 = 20\text{m}$

iii) $v = u + at = 0 + 10 \times 2 = 20\text{ ms}^{-1}$

iv) $Fs = 15 \times 20 = 300\text{ J}$

Work done by gravitational force

Converts gpe to k.e.

$\frac{1}{2}mv^2 = \frac{1}{2} \times 1.5 \times 20^2 = 300\text{J}$

v) $Ft = 15 \times 2 = 30\text{ Ns}$

= Change in momentum

$= mv - mu$

$= 1.5 \times 20 - 0 = 30\text{ Ns}$

4)

i) $mu = 0.06\text{ kg} \times 20\text{ ms}^{-1}$

$= 1.2\text{ kgms}^{-1}$

ii) At top $v = u + at$

$v = 0, \quad 0 = 20 - 10t$

$\Rightarrow t = 2\text{ s}$

iii) At top $mv = 0\text{ kgms}^{-1}$

iv) Impulse = change in momentum

$\therefore = 1.2\text{ kgms}^{-1}$ or 1.2 Ns

5)

i) Impulse = change in momentum reqd

$= 0.425\text{ kg} \times 5\text{ ms}^{-1}$

$= 2.125\text{ Ns}$

ii)

a) $Ft = 2.125$

$F = \frac{2.125}{t}$

$F = \frac{2.125}{0.1} = 21.25\text{ N}$

b)

$F = \frac{2.125}{0.05} = 42.5\text{ N}$

iii) Same impulse required but longer time therefore smaller force required since

$Ft = \text{Impulse}$

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6) i) Impulse = Change in momentum

$= 0.9 \times 10^3 \text{ kg} \times 13.2 \text{ ms}^{-1}$

$= 11880 \text{ Ns}$

ii) Ft = Impulse

$F = \frac{\text{Impulse}}{t} = \frac{11880}{0.12}$

$F = 99000 \text{ N}$

iii) $F = ma$

$a = \frac{F}{m} = \frac{99000}{900}$

$a = 110 \text{ ms}^{-2} = 11g$

iv) For a given collision the impulse is fixed. However, by extending the time of the impact, the average force can be reduced.

7) i) $v^2 = u^2 + 2as$

$v^2 = 0 + 2 \times 9.8 \times 1.5$

$v^2 = 29.4$

$v = 5.42 \text{ ms}^{-1}$

ii) Impulse = change in momentum

$= mv = 20\text{kg} \times 5.42 \text{ ms}^{-1}$

$= 108.4 \text{ Ns}$

iii) Equal and opposite impulse = 108.4Ns

iv) $Ft = J$

$F = \frac{J}{t} = \frac{108.4}{0.2}$

Average force $F = 542 \text{ N}$

8) i) +ve direction →

$mu = 10 \times 10^3 \text{ kg} \times 3 \text{ ms}^{-1}$

$= 3.0 \times 10^4 \text{ kg ms}^{-1}$

ii) $mv = 10 \times 10^3 \text{ kg} \times -1.5 \text{ ms}^{-1}$

$= -1.5 \times 10^4 \text{ kg ms}^{-1}$

ie in opposite direction to original

iii) Impulse = change in momentum

$= -1.5 \times 10^4 - 3.0 \times 10^4$

$= -4.5 \times 10^4 \text{ Ns}$

− sign indicates direction of impulse is in opposite direction to original motion.

iv) Area under graph represents impulse or change in momentum

v) $|J| = 45000 \text{ Ns}$

Area of $\Delta = \frac{1}{2}$ base × height

$\frac{1}{2} \times 0.2 \times h = 45000$

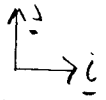
$\Rightarrow h = 450{,}000 \text{ N} = \text{Max } F$

9)

i)

ii)

iii)



Before

$\underline{u} = 3.5\cos 60\,\underline{i} - 3.5\sin 60\,\underline{j}$

$\underline{u} = 1.75\,\underline{i} - 1.75\sqrt{3}\,\underline{j}$

After

$\underline{v} = 2\cos 30\,\underline{i} + 2\sin 30\,\underline{j}$

$\underline{v} = \sqrt{3}\,\underline{i} + \underline{j}$

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iv)

Impulse = change in momentum

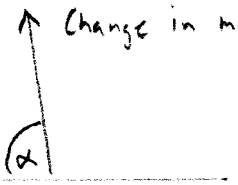
$= m\underline{v} - m\underline{u}$

$= m(\underline{v} - \underline{u})$

$= 0.08\left(\sqrt{3}\,\underline{i} + \underline{j} - (1.75\,\underline{i} - 1.75\sqrt{3}\,\underline{j})\right)$

$= 0.08\left(-0.0179\,\underline{i} + 4.031\,\underline{j}\right)$

$= -1.432\times10^{-3}\,\underline{i} + 0.322\,\underline{j}$



$\alpha = \tan^{-1}\dfrac{0.322}{1.432\times10^{-3}} = 89.7^\circ$

Hardly any change in momentum parallel to cushion

10)

i)

$\underline{J} = m\underline{v} - m\underline{u}$

$J = m(\underline{v} - \underline{u})$

$-4.8\,\underline{i} + 1.2\,\underline{j} = 0.15\left(\underline{v} - (12\,\underline{i} - 8\,\underline{j})\right)$

$\begin{pmatrix} -4.8 \\ 1.2 \end{pmatrix} = 0.15\begin{pmatrix} v_1 - 12 \\ v_2 + 8 \end{pmatrix}$

$\begin{pmatrix} \frac{-4.8}{0.15} \\ \frac{1.2}{0.15} \end{pmatrix} = \begin{pmatrix} v_1 - 12 \\ v_2 + 8 \end{pmatrix}$

$\begin{pmatrix} v_1 \\ v_2 \end{pmatrix} = \begin{pmatrix} -32 + 12 \\ 8 - 8 \end{pmatrix} = \begin{pmatrix} -20 \\ 0 \end{pmatrix}$

$\underline{v} = -20\,\underline{i}$

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ii)

$\underline{J} = m\underline{v} - m\underline{u}$

$\underline{J} = 0.15(\underline{v} - \underline{u})$

$\underline{J} = 0.15\left(\begin{pmatrix} 14 \\ 4 \\ 3 \end{pmatrix} - \begin{pmatrix} -20 \\ 0 \\ 0 \end{pmatrix}\right)$

$\underline{J} = 0.15\begin{pmatrix} 34 \\ 4 \\ 3 \end{pmatrix}$

$\underline{J} = \begin{pmatrix} 5.1 \\ 0.6 \\ 0.45 \end{pmatrix}$

$\underline{J} = 5.1\,\underline{i} + 0.6\,\underline{j} + 0.45\,\underline{k}$

$|J_1| = \sqrt{(-4.8)^2 + 1.2^2} = 4.95$ Ns

$|J_2| = \sqrt{5.1^2 + 0.6^2 + 0.45^2} = 5.15$ Ns

2nd player Fatima hits harder

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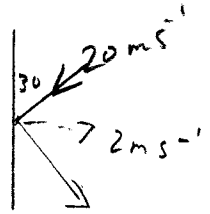
11) i) Vertical component of velocity unchanged



Horizontal component of velocity changed by $20\sin 30 + 2$

$= 12\ ms^{-1}$

Change in momentum

$4 \times 10^{-3}\ Kg \times 12\ ms^{-1}$

$= 0.048\ Kg\,ms^{-1}$

Impulse of window on hailstone

a) $= 0.048\ Ns$

at 90° to window →

Impulse of hailstone on window

b) $= 0.048\ Ns$

at 90° to window ←

ii)

Hailstones 540 per min

$= 9$ per second

Impulse per second $= 9 \times 0.048 = 0.432\ N$

∴ Average Force $= 0.432\ N$

12)

i) Area under graph = impulse or change in momentum.

ii) Total impulse

$= \frac{1}{2} \times 1 \times 2500 + \frac{1}{2}(2500 + 3500) \times 1 + \frac{1}{2}(3500 + 4500) \times 2$

$= 1250 + 3000 + 8000 \quad Ns$

$= 12250\ Ns$

iii)

Impulse = change in momentum

$mv - mu = 12250$

$2500v - 0 = 12250$

$v = 4.9\ ms^{-1}$