MOMENTUM AND IMPULSE

1. a) Initial momentum = $2 \times 3 + 3 \times 1$ — B1
Final momentum = $5 \times v$ — B1
Conservation of momentum — M1
$9 = 5v \Rightarrow v = 1.8\ ms^{-1}$ — A1 cao
[4]

b) $2 \times 3 + 3 \times -1 = 5v$ — M1 A1
$v = 0.6\ ms^{-1}$ — A1 cao
[3]

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2. Initial momentum = $m \times 4$ — B1
Final momentum = $2m \times v$ — B1
Conservation of momentum — M1
$4m = 2mv \Rightarrow v = 2\ ms^{-1}$ — A1 cao
[4]

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3. 30 grammes is 0.03kg — B1
Initial momentum = 0 — B1
After firing, momentum = $6v - 0.03 \times 400$ — M1 A1
Conservation of momentum — B1
$0 = 6v - 0.03 \times 400 \Rightarrow v = 2\ ms^{-1}$ — A1 cao
[6]

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4. a) For A and B:
Initial momentum = $6 \times 5 + 4 \times 3$ — M1 A1
Final momentum = $4 \times v$ — A1
Conservation of momentum: $42 = 4v \Rightarrow v = 10.5\ ms^{-1}$ — M1 A1 cao
[5]

b) For B and C:
Conservation of momentum $\Rightarrow 4 \times 10.5 = 4B + 2C$ — M1 A1
Difference in speeds $\Rightarrow 3 = C - B$
Solving: B=6; C=9 — M1 A1 A1
[5]

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5. Initial momentum = $m \times u - M \times u$ } — M1
Final momentum = $(m + M)\frac{1}{2}u$ — A1
Conservation of momentum — M1
$m - M = \frac{1}{2}(m + M)$ — A1
$2m - 2M = m + M$
$m = 3M$ so m: M is 3:1 — A1
[5]

MOMENTUM AND IMPULSE

6. a) $\mathbf{F}t = m(\mathbf{v} - \mathbf{u})$ B1
$6\mathbf{F} = 10(30\mathbf{i} - 24\mathbf{j})$ M1 A1
$\mathbf{F} = 50\mathbf{i} - 40\mathbf{j}$ A1
[4]

b) Initial momentum $=10\ (33\mathbf{i} - 22\mathbf{j})$ } M1
Final momentum $=20\mathbf{v}$ } A1 (both)
so $\mathbf{v} = 16.5\ \mathbf{i} - 11\mathbf{j}$ A1
speed $= \sqrt{\left[(16\tfrac{1}{2})^2 + 11^2\right]} = 19.8 \text{ms}^{-1}$ M1 A1
[5]

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7. Initial momentum $= 5 \times 4 = 20$ M1 A1
Final momentum $= 8 \times v$ A1
Conservation of momentum M1
$20 = 8v \Rightarrow v = 2.5 \text{ ms}^{-1}$ A1

For A:
Impulse = change in momentum $= 3 \times 2.5 = 7.5$ Ns M1 A1
[7]

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8. a) Conservation of momentum B1
$m \times 0.5 = 4m \times v$ M1
$v = 0.125$ A1
[3]

b) For Thomas:
Impulse = change in momentum $= 3m \times 0.125 = 0.375m$ M1 A1
In direction of motion of Annabel A1
[3]

c) Initial kinetic energy $= 0.5 \times m \times 0.5^2 = 0.125m$ M1 A1
Final kinetic energy $= 0.5 \times 4m \times 0.125^2 = 0.03125m$ A1 ft

Loss of kinetic energy. $= 0.09375m$ J M1 A1 cao
[5]

d) Treated as particles B1
[1]

MOMENTUM AND IMPULSE

9. a) Initial momentum = $4(3\mathbf{i} - 2\mathbf{j}) + 7(3\mathbf{i} + 2\mathbf{j})$ — M1 A1
Final momentum = $7(a\mathbf{i} + b\mathbf{j})$ — A1
Conservation of momentum — M1
$33\mathbf{i} + 6\mathbf{j} = 7(a\mathbf{i} + b\mathbf{j}) \Rightarrow a = \frac{33}{7}, \quad b = \frac{6}{7}$ — A1 A1
[6]

b) Spheres modelled as particles — B1
[1]

10.a) i) Impulse = change in momentum of white ball — B1
$J = mu \Rightarrow u = \frac{J}{m}$ — M1 A1
[3]

ii) Initial momentum = $mu = J$
Final momentum = $mv + mV$ — M1 A1
Conservation of momentum $J = mv + mV$ — M1
so $v = \frac{J - mV}{m}$ — M1 A1
[5]

b) Initial kinetic energy $= \frac{1}{2}mu^2 = \frac{J^2}{2m}$ — M1 A1 ft

Final kinetic energy $= \frac{1}{2}mv^2 + \frac{1}{2}mV^2$ — M1

$= \frac{1}{2}m\left(\frac{J - mV}{m}\right)^2 + \frac{1}{2}mV^2$ — A1 ft

$= \frac{J^2}{2m} - JV + mV^2$ — A1 cao

So loss in kinetic energy $= \frac{J^2}{2m} - \frac{J^2}{2m} + JV - mV^2 = JV - mV^2$ — M1 A1 cao
[7]

11.a) Initial momentum = 0.15×0.6
Final momentum $= 0.2 \times v$ — M1 A1
Conservation of momentum — M1
$0.15 \times 0.6 = 0.2v \Rightarrow v = 0.45\ ms^{-1}$ — A1 cao
[4]

b) Impulse on peg = change in momentum of peg — B1
$= 0.05 \times 0.45 = 0.0225$ — M1
Impulse is 0.0225 Ns downwards — A1 A1
[4]

MOMENTUM AND IMPULSE

12.a) Impulse = change in momentum B1

For section A:

change in momentum = $10 \times 180 - 10 \times 100$ so magnitude of impulse = 800 Ns M1 A1

[3]

b) Initial momentum $=15 \times 100$ M1 A1

Final momentum $=10 \times 180 + 5 \times v$ A1

Conservation of momentum

$1500 = 1800 + 5v \Rightarrow v = -60$ A1

B is moving under constant acceleration $\Rightarrow$ use equations of motion B1

$s = 5000$

$s = ut + \frac{1}{2}at^2$ so $5000 = 60t + \frac{1}{2}(10t^2)$ M1

$t^2 + 12t - 1000 = 0$ so $t = 26$ seconds M1 A1

[8]

c) Include air resistance / do not assume g is constant B1 (either)

[1]