Questions on Momentum MS

1. Momentum

Use of $p = m\upsilon$ **(1)**

Total momentum = 0.32 kg m s^{-1} or N s **(1)** 2

Velocity

Use of conservation of momentum **(1)**

0.062 m s^{-1} [Allow e.c.f. from wrong first answer] **(1)**

East/in same direction as B moved originally **(1)** 3

[Only award last mark if momenta subtracted in first part]

[5]

2. 30 m ÷ (5 × 0.62 s)
= 9.7 m s^{-1} 2

(7000 kg × 9.7 m s^{-1}) [allow 10 m s^{-1} as e.c.f.]
= 68 000 (kg m s^{-1}) 2

Momentum before = momentum after
(7000 kg × 9.7 m s^{-1}) +0 = (7000 kg +5000 kg) × υ
υ = (7000 kg × 9.7 m s^{-1}) ÷ (12 000 kg)
= 5.7 m s^{-1} [allow 5.8 if e.c.f. of 10 m s^{-1}] 3

Force = change in momentum ÷ time
= 7000 kg × [9.7 m s^{-1} –5.7 m s^{-1}]÷ 0.30 s
= 93 000 N [98 000 N if 10 m s^{-1}used] 3

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3. Experiment
2 light gates **(1)**
Gate gives time trolley takes to pass [not just 'the time'] **(1)**
Speed = length of 'interrupter'/time taken **(1)**

OR

2 ticker timers **(1)**
Dots at known time intervals **(1)**
Speed = length of tape section/time taken **(1)** 3
[ruler + clock could obtain third mark only, specifying a length/time]

Total momentum of trolleys
Zero **(1)**
It was zero initially **or** momentum is conserved [consequent] **(1)** 2

Speed *v* of A
Use of momentum = mass × velocity **(1)**
Use of mass × speed (A) = mass × speed (B) **(1)**
1.8 m s^{-1} [ignore -ve signs] **(1)** 3

[8]

4. Momentum and its unit

Momentum = mass × velocity 1

kg m s^{-1} or N s 1

Momentum of thorium nucleus before the decay

Zero 1

Speed of alpha particle/radium nucleus and directions of travel

Alpha particle because its mass is smaller/lighter 1

So higher speed for the same (magnitude of) momentum
OR N3 argument 1

Opposite directions/along a line 1

[6]

5. Momentum of driver:

Correct use of $p = m\upsilon$ [OR with numbers] **(1)**

= 1500 N s OR 1500 kg m s^{-1} **(1)** 2

Average resultant force:

Correct choice of $F \times t = \Delta p$	OR	$F = ma$ **(1)**	
$F \times 0.07$ (s) = 1500 (N s)		$F = 50 \times 429/50 \times 30/0.07$ **(1)**	
= 21 kN		= 21 kN **(1)**	3

[Ignore sign of answer]

Why resultant force is not the same as force exerted on driver by seatbelt:

Air bags /floor/friction/seat/steering wheel **(1)**
[Named force other than weight/reaction] 1

[6]

6. Mass of head of mallet
Selecting density x volume **(1)**
Correct substitutions **(1)**
Mass = 1.15 (kg) [3 significant figures, minimum] **(1)** 3

Momentum change

$p = m\upsilon$ used **(1)**
Δp = 1.15 or 1.2 kg (4.20 + 0.58) m s^{-1} **(1)**
= 5.50 / 5.74 kg m s^{-1}/N s **(1)** 3

Average force

Their above / 0.012 s **(1)**

F = 458/478 N [e.c.f. Δp above] **(1)** 2

Value for force

Handle mass/weight/ head weight/force exerted by user (handle)
neglected **(1)** 1

Effectiveness of mallet with rubber head

Δt goes up/Δp goes up **(1)**

$\Rightarrow$ *less* force, *less* effective/*more* force, *more* effective [consequent] **(1)** 2

[11]

7. (a) Newton's Second Law of Motion

(The) force (acting on a body) is proportional/equal to the rate of **(1)**
change of momentum **(1)**
and acts in the direction of the momentum change
[accept symbols if all correctly defined for the first of these marks]
[ignore any information that is given that is not contradictory] 2

(i) Calculate the mass

Correct calculation for volume of air reaching tree per second
[Do not penalise unit error or omission of unit] **(1)**
Correct value for mass of air to at least 3 sig fig [246 kg. No ue.] **(1)**
[If 1.23 × 10 × 20 = 246 kg is seen give both marks.
Any order for the numbers]

Example

$20 \text{ ms}^{-1} \times 10\text{m}^2 = 200 \text{ m}^3$
$1.23 \text{ kg m}^{-3} \times 200 \text{ m}^3 = 246 \text{ kg}$

(ii) Calculate the momentum

Answer: [(246 kg × 20 m s^{-1} =) 4920 kg m s^{-1}]
[Accept (250 kg × 20 m s^{-1} =) 5000 kg m s^{-1}. Accept 4900 kg m s^{-1}. **(1)** 2
Ecf value for mass. Ignore signs in front of values.]

(iii) Magnitude of the force
Answer: [*F* = 4920 N or 5000 N or 4900 N.]
[Ecf value from b(ii). Ignore signs in front of values] **(1)** 2

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8. Definition of linear momentum:

Mass × velocity [Words or defined symbols; NOT *ft*] **(1)** 1

Newton's second law:

Line 3 only **(1)** 1

Newton's third law:

Line 2 OR 1& 2 **(1)** 1

Assumption:

No (net) external forces/no friction/drag **(1)**

In line 3 (he assumes the force exerted by the other trolley is
the resultant force) [Only if 1st mark earned] **(1)** 2

Description of how it could be checked experimentally that momentum is conserved in a collision between two vehicles:

Suitable collision described and specific equipment to
measure velocities [e.g. light gates] **(1)**

Measure velocities before and after collision **(1)**

How velocities calculated [e.g. how light gates used] **(1)**

Measure masses / use known masses/equal masses **(1)**

Calculate initial and final moment a and compare OR
for equal trolleys in inelastic collision, then $v_1 = ½ v_2$ **(1)** Max 4

[9]

9. Calculation of resultant force:

$[a = (\upsilon - u)/t = 16 \text{ m s}^{-1}[(4 \times 60) \text{ s}]$

$= 0.0666 \text{ m s}^{-2}$

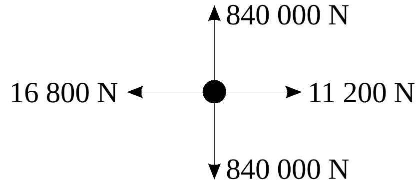
$F = ma = 84\,000 \text{ kg} \times 0.0666 \text{ m s}^{-2} = 5600 \text{ N}]$

OR

Use of $\frac{(\upsilon - u)}{t}$	use of $m\upsilon$	**(1)**	
Use of $F = ma$	use of $\frac{m\upsilon}{t}$	**(1)**	
5600 N	5600 N	**(1)**	3

Free-body force diagram:

Diagram [truck can be just a blob] showing:



823 200 – 840 000 N down		**(1)**	
same as down	up	**(1)**	
11 200 N	either way	**(1)**	
correct resultant	to left		
[e.c.f.]			
			4

[Ignore friction. Each extra force –1]

Calculation of average power:

Power = KE gained/time = $½mv^2/t$ OR KE = 3.84×10^8 J	**(1)**	
= 3.84×10^8 J/(4 × 60) s	**(1)**	
= 1.60×10^6 W [OR J s^{-1}]	**(1)**	3

Other credit-worthy responses:

$½\, m\upsilon^2$	Fv	$\frac{Fd}{t}$	**(1)**	
$\frac{1}{2} \times \frac{3 \times 10^6 \times 16^2}{240}$	$3 \times 10^6 \times 0.666 \times 8$	$\frac{3 \times 10^6 \times 0.666 \times 1920}{240}$ [e.c.f. 0.666 and 1920 possible]	**(1)**	
1.6×10^6 W	1.6×10^6 W	1.6×10^6 W	**(1)**	3

Calculation of average current:

$P = IV = I \times 25\,000$ V $= 1.60 \times 10^6$ W   Use of $P = IV$ 2

[12]