Question number	Answer	Notes	Marks
1 (a) (i)	$p = m \times v$	accept answer in words, standard symbols or rearranged	1
(ii)	statement of conservation of momentum; calculation of momentum before seen; use of correct mass for momentum after; evaluation of velocity; e.g. $m_1v_1 = m_2v_2$ 43.2 x 4.10 OR 177(.12) seen (m_2=) 45.7 (v=) 3.88 (m/s)	 allow in words 3.9, 3.876	4
(b)	MP1. boy and skateboard move backwards/in opposite direction to the ball; Either MP2. because of conservation of momentum/eq; MP3. because of Newton's 3rd law/eq;	 total marks = 7	2

Question number	Answer	Notes	Marks
2 (a) (i)	lever arm / bolt moves to the left;		1
(ii)	to return the metal bar (and lever) to the right/eq	allow pulls it back (again)	1
(b) (i)	$F_1d_1 = F_2d_2$;	accept answer in words, standard symbols or rearranged clockwise (moments) = anticlockwise (moments	1
(ii)	substitution; rearrangement; evaluation; e.g. $110 \times 22 = 38 \times F_2$ $F_2 = \frac{110 \times 22}{38}$ 63.7 (N)	rearrangement and substitution in either order 63.684 (N) -1 for incorrect rounding	3
(iii)	any two from MP1 (since distance to A greater) moment is greater; MP2 distance to B is constant / still 110 cm; MP3 (hence) force will increase;	allow correct re-calculation with d_B total marks = 8	2

Question number	Answer	Notes	Marks
3 (a) (i)	momentum = mass × velocity;	symbols and rearrangements e.g. p = m × v	1
(ii)	substitution into correct equation; evaluation; e. (momentum =) 0.23 × 13 = 3.0 (kg m/s)	 allow 3, 2.99	2
(b)	explanation in terms of conservation of momentum OR Newton's third law **conservation of momentum** - any 3 of: MP1. mention of conservation of momentum; MP2. momentum of snowball **and** skater; MP3. (are) equal and opposite; MP4. because momentum initially zero; OR **Newton's third law** - any 3 of: MP1. mention of {action and reaction / Newton III law}; MP2. forces on skater **and** snowball; MP3. (are) equal and opposite; MP4. idea that (magnitude of) rate of change of momentum is same for both forces;	 allow 'her' or similar to mean the skater allow e.g. -3.0 (kg m/s) allow 'her' or similar to mean the skater condone 'push' for force **if no other mark awarded**, allow 'because there is no / little friction' for 1 mark	3

(c)	explanation in terms of momentum OR acceleration OR pressure **momentum** - any 3 of: MP1. idea of increased time (of impact); MP2. **same** change in momentum; MP3. force is rate of change in momentum; MP4. reduces force (on knee); OR **acceleration** - any 3 of: MP1. idea of increased distance/time (to slow down); MP2. **same** change in velocity / speed; MP3. reduces acceleration; MP4. reduces force (on knee); OR **pressure** - any 3 of: MP1. idea of increased area (in contact with ground / knee); MP2. reduced force; MP3. pressure = force ÷ area; MP4. reduces pressure (on knee);	allow F = change in momentum ÷ time allow same force symbols	3

Total 9 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4 (a)</td><td>Vector quantities –
Force, velocity

Scalar quantities –
Distance, speed</td><td>Four correct ticks = 2 marks
minus 1 each mistake /omission
two ticks in a row is a mistake

<table><tr><th>Quantity</th><th>Vector</th><th>Scalar</th></tr><tr><td>distance</td><td></td><td>✓</td></tr><tr><td>force</td><td>✓</td><td></td></tr><tr><td>momentum</td><td>(✓)</td><td></td></tr><tr><td>speed</td><td></td><td>✓</td></tr><tr><td>velocity</td><td>✓</td><td></td></tr></table></td><td>2</td></tr>
<tr><td>(b) (i)</td><td>Momentum = mass x velocity;</td><td>Allow equivalent rearrangement or symbols
p= m x v</td><td>1</td></tr>
<tr><td>(ii)</td><td>Substitution into correct equation;
Calculation;
e.g.
1500 x 20
30 000 (kg m/s)</td><td>Allow 3 x 10^4
Full marks for correct answer without working (bald answer)</td><td>2</td></tr>
</table>

Question number	Answer	Notes	Marks
4 (c) (i)	Substitution into correct equation; Calculation; e.g. $\frac{22500}{0.14}$ 160 000 (N)	No mark for the equation as it is given on page 2 Accept 2 or more sf, e.g. 161 000, 160 714 Full marks for bald correct answer	2
(ii)	Any three of - MP1. Longer time (of impact); MP2. **Same** momentum change (with or without a seatbelt); MP3. Reduces force; MP4. Passenger stays on seat / is not thrown from vehicle/eq;	Do not credit the equation as it is given on page 2 Allow slows down more gradually	3

(Total for Question 4 = 10 marks)

Question number	Answer	Notes	Marks
5 (a)	Any 2 from air bags; side impact beams/bars; crumple zones /collapsible bumpers; collapsible steering column /wheel;	Allow references to strong / laminated / safety glass ignore unqualified bumpers	2
(b) (i)	Any four from MP1. same momentum change (with or without a seatbelt); MP2. (but) time of impact increases; MP3. (which) reduces rate of momentum change; MP4. (therefore) reducing the (average) force; MP5. the seat belt stretches (during collision); MP6. (which) increases the area over which the force acts; MP7. (hence) pressure on body reduces;	Ignore • references to momentum reducing • word equation	4
(b) (ii)	A sensible suggestion; e.g. there is a higher momentum (transfer in collision) there is a larger force during impact straps have a greater area over which force acts larger area of straps reduces the pressure		1

(c)	Momentum (of car and dummy) reduces to zero; OR All momentum is absorbed by the Earth;		1

(Total for Question 5= 8 marks)

Question number	Answer	Notes	Marks
6 (a)	momentum = mass × velocity;	Allow rearrangements and standard abbreviations p = m x v	1
(b)	Equation; Substitution and rearrangement; Evaluation; e.g. $m_1 \times v_1 = m_2 \times v_2$ 10 000 x 4.5 / 1500 30(m/s)	 bald answer = 3 marks POT =-1	3

(Total for Question 6= 4 marks)