My Question Paper

1. *(a)* Complete the sentence below. [2]

The law of conservation of momentum states that in a collision or explosion ....

....

....

(b) (i) Two cars of equal mass, 800 kg, collide. Before the collision, car **B** is at rest while car **A** has a constant velocity of 15 m/s. In the questions that follow, ignore the effects of friction.

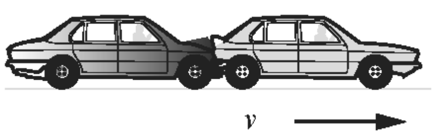
Before collision

Use an equation from page 2 to calculate the momentum of car **A** before the collision. [2]

Momentum = ... kg m/s

(ii) After the collision, the two cars are stuck together.

After collision



Use the equation:

$$\text{velocity} = \frac{\text{momentum}}{\text{mass}}$$

to calculate the velocity *v* of the cars after the collision. [3]

Velocity = ... m/s

(iii) During the collision, car **A** exerts a force of 16 000 N to the right on car **B**. What force does car **B** exert on car **A** during the collision? [2]

....

(c) Suppose both cars had been travelling towards each other at the same speed.

(i) What would their velocity be after a head-on collision if they stuck together on impact? [1]

....

(ii) Explain your answer. [2]

....

....

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2. On 14 October 2012 Felix Baumgartner created a new world record when he jumped from a stationary balloon at a height of 39 km above the surface of the Earth. At 42 s of free fall he reached a terminal velocity of 373 m/s, which was greater than the speed of sound. The total mass of Felix and his suit was 118 kg.

(a) Explain in terms of weight and air resistance how terminal velocity is reached. [3]

....

....

....

....

....

(b) (i) Use an equation from page 2 to calculate Felix's change in momentum in the first 42 s of his fall. [2]

change in momentum = ... kg m/s

(ii) Use an equation from page 2 to calculate the mean resultant force acting on him during the first 42 s. [2]

mean resultant force = ... N

(iii) Calculate the mean value of the air resistance force during the first 42 s. [3]

mean air resistance force = ... N

(c) At 39 km the air particles are very far apart. Explain how jumping from this height allowed Felix to reach such a high terminal velocity. [2]

....

....

....

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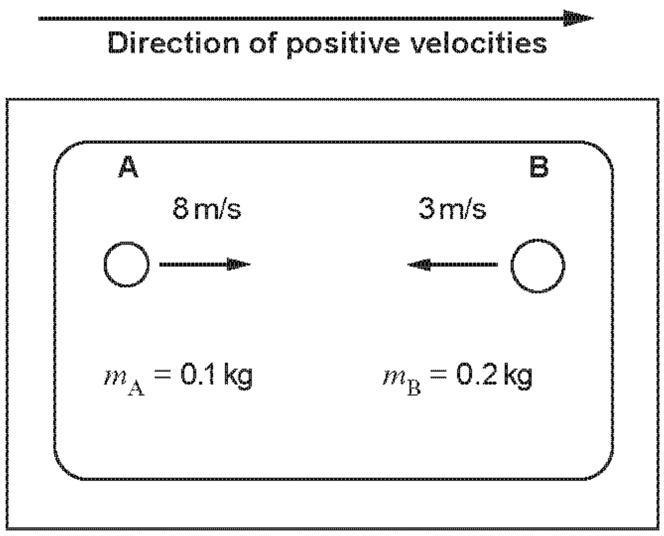
3. *(a)* A sliding disc **A** of mass (m_A) 0.1 kg travelling with a velocity of +8 m/s on a frictionless table hits another disc **B** of mass (m_B) 0.2 kg travelling with a velocity of –3 m/s.



(i) Use an equation from page 2 to calculate the initial momentum of disc **A**. [2]

momentum = ... kg m/s

(ii) Calculate the initial momentum of disc **B**. [1]

momentum = ... kg m/s

(iii) Calculate the **total** momentum before the collision. [1]

total momentum = ... kg m/s

(iv) Write down the **total** momentum after the collision. [1]

total momentum = ... kg m/s

(v) After the collision, disc **A** stops moving.

Use the equation:

$$\text{velocity} = \frac{\text{total momentum}}{\text{mass}}$$

to calculate the velocity of disc **B** after the collision. [2]

velocity of disc **B** = ... m/s

(b) Disc **A** decelerates at 160 m/s^2 during the collision.

(i) Use the equation:

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

to calculate how long the collision takes. [2]

time = ... s

(ii) Disc **A** applies a mean force of 1.6 N to disc **B** during the impact. Write down the **size** and **direction** of the mean force applied to disc **A** by disc **B** in the collision. [2]

....

....

(c) Use an equation from page 2 to calculate the loss of kinetic energy in the collision. [3]

energy lost = ... J

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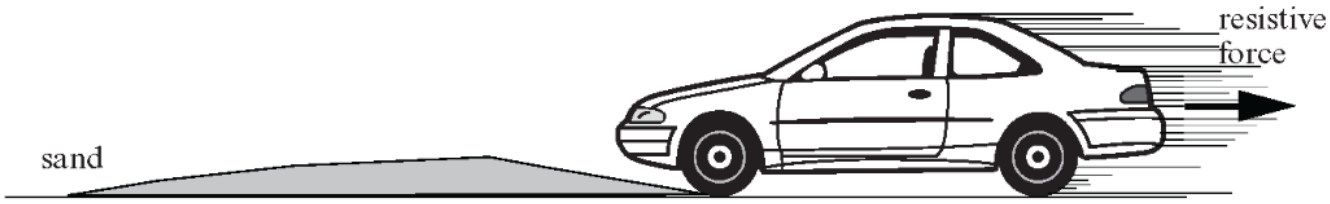
4. A car of mass 1 500 kg, travelling at 15 m/s has its speed reduced to 5 m/s when it travels 7.5 m through a pile of sand in the road.



(a) Use an equation from page 2 to calculate the loss of kinetic energy of the car. [3]

Loss in kinetic energy = ...

(b) Use your answer to part *(a)* along with an equation from page 2 to find the (mean) resistive force produced by the sand during the collision. [3]

Resistive force = ... N

(c) Write down the value of the horizontal force that acts on the **sand** in this collision. [1]

Force on the sand = ... N

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5. A girl catches and stops a ball of mass 0.15 kg which is moving at a speed of 20 m/s.

(a) (i) Use the equation:

momentum = mass × velocity

to calculate the change in momentum of the ball. [2]

Momentum change = ... kg m/s

(ii) Use an equation from page 2 to calculate the force applied by the girl if the ball is stopped in 0.5 seconds. [2]

Force = ... N

(iii) The girl now doubles the time taken to stop the ball by moving her hands towards her as she catches it. What is the size of the force now? [1]

Force = ... N

(b) In some situations people have to be stopped suddenly and safely. The force on them is reduced by increasing the stopping time.

(i) Name a situation in which this happens. [1]

....

(ii) Describe how the stopping time is increased. [1]

....

....

7

6. *(a)* A car is travelling at 20 m/s before slowing down to a velocity of 5 m/s.

(i) Calculate the change in velocity of the car. [1]

change in velocity = ... m/s

(ii) The driver of the car has a mass of 60 kg. Use the equation:

$$\text{momentum} = \text{mass} \times \text{velocity}$$

to calculate the change in momentum of the driver. [1]

change in momentum = ... kg m/s

(iii) The car slowed down for 6 s. Use the equation:

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

to calculate the size of the force acting on the driver during braking. State the unit. [2]

force = ...

unit ....

(b) In another situation, the car slowed down from 20 m/s to 5 m/s in less time. Explain what effect this has on the force acting on the driver. [2]

....

....

....

(c) Seat belts help to keep drivers and passengers safer when the car stops suddenly during an accident.
Name **two** *other* safety features that help to do this. [2]

1. ....

2. ....

8

7. *(a)* State Newton's first law of motion. [2]

....

....

....

(b) (i) A car experiences an accelerating force of 2 250 N for 8 seconds. Use an equation from page 2 to calculate its change in momentum. [2]

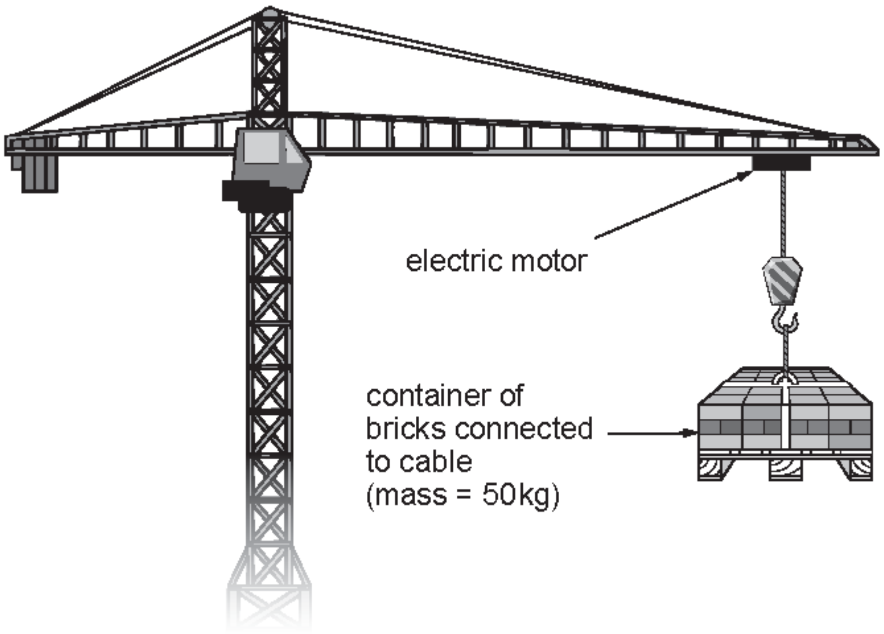
Change in momentum = ... kg m/s

(ii) If the car was initially travelling at 5 m/s and has a mass of 900 kg, use an equation from page 2 to calculate its final velocity. [2]

Final velocity = ... m/s

6

8. A crane is used on a building site to vertically lift building materials. It uses an electric motor to winch a cable that is connected to a container full of bricks of mass 50 kg.



(a) (i) To lift the container of bricks the electric motor is supplied with a voltage of 120 V and a current of 5 A. Using an equation from page 2, calculate the power developed by the motor. [2]

power = ... W

(iii) The container of bricks is lifted through a height of 14 m. Using an equation from page 2, calculate the gain in gravitational potential energy whilst using the electric motor to lift the container of bricks. (g = 10 N/kg) [2]

potential energy gain = ... J

(iv) State why the answers to parts (ii) and (iii) are different. [1]

....

....

(b) The motor is stopped when the container of bricks reaches a height of 14 m.
It is held stationary above the ground.

(i) Calculate the force in the cable. (g = 10 N/kg) [2]

force = ... N

(ii) The cable snaps. Using Newton's laws, explain the motion of the container of bricks. [2]

....

....

....

(iii) Using your answer to *(a)*(iii) and an equation from page 2, calculate the **maximum** impact velocity of the container of bricks as they hit the ground. [3]

impact velocity = ... m/s

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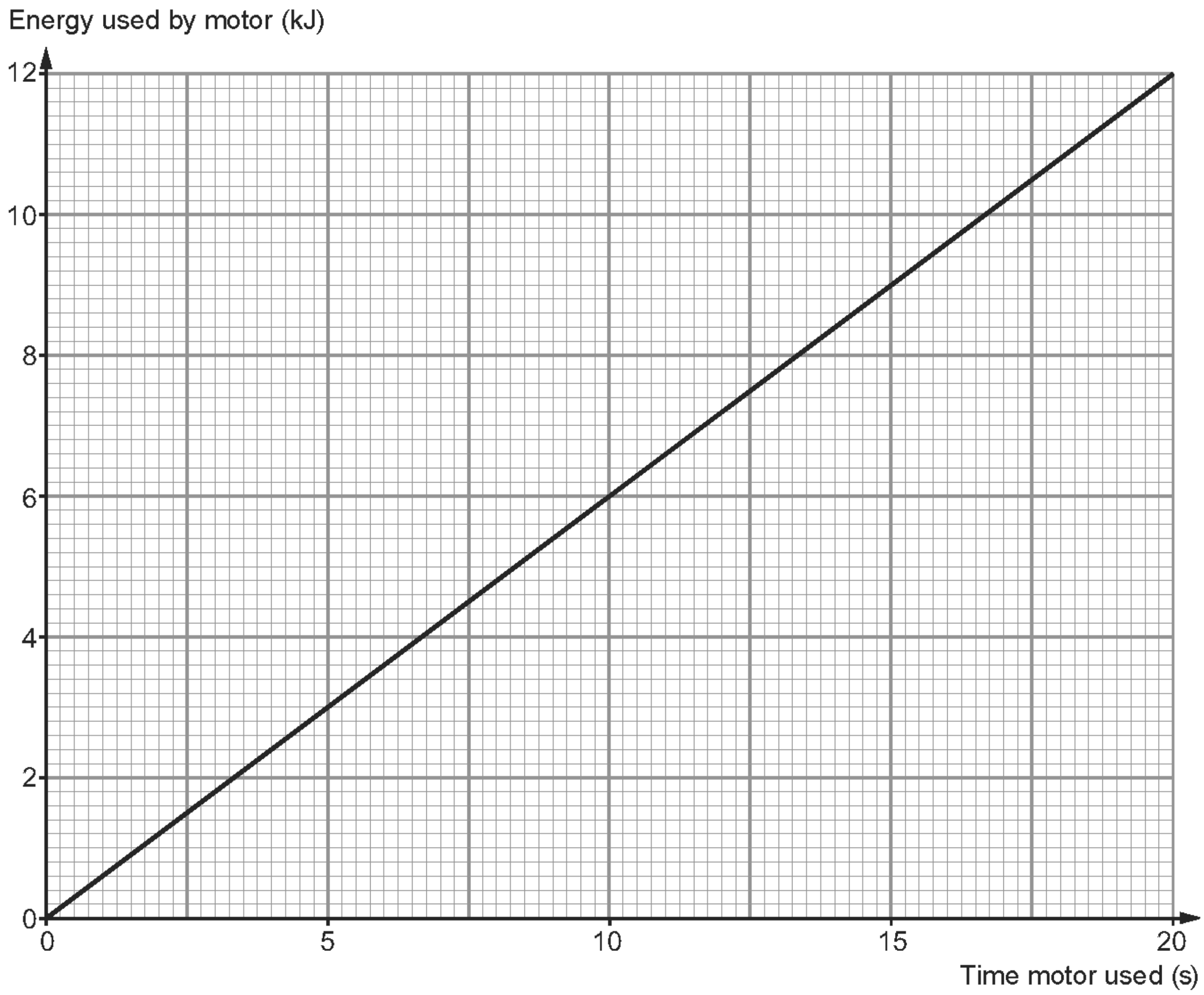
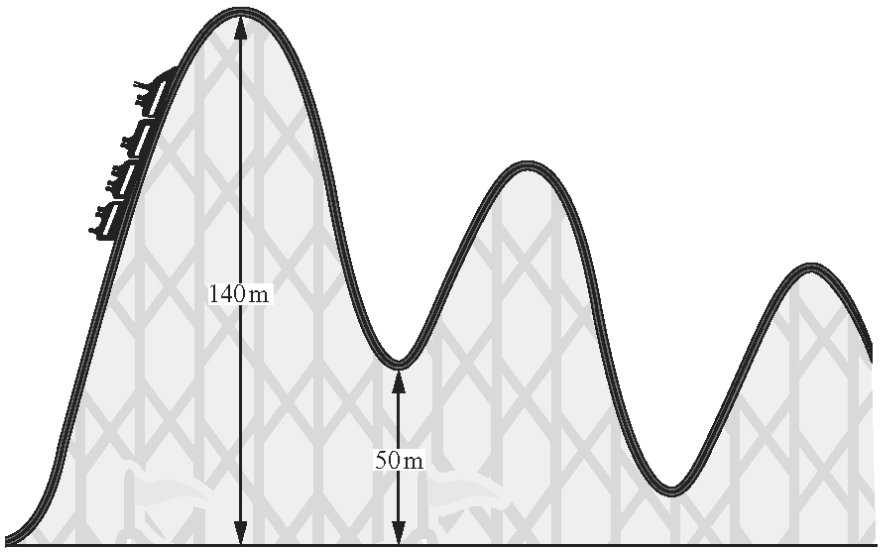
(ii) The energy used by the motor increases with time as shown in the graph below.



The motor is used for 15 seconds to lift the container of bricks. State the amount of energy **(in J)** used by the motor to lift the container of bricks. [1]

energy = ... J

9. A rollercoaster car has no engine. The car is pulled to the top of the first peak at the beginning of the ride, but after that the car must complete the ride on its own. Every peak on a rollercoaster must be lower than the one before it.



(a) Explain in terms of energy transfers how the car is able to complete the ride after being pulled to the top of the first peak and why each peak must be lower than the one before it. [6 QWC]

(b) One of the world's tallest rollercoasters has an initial peak of height 140 m. After reaching the top, the car first falls to a height 50 m above the ground before it continues on its journey.

The mass of the car and passengers is 1 200 kg.

(i) Use equations from page 2 to calculate the theoretical maximum velocity of the car after this first fall. (g = 10 m/s^2) [4]

Maximum velocity = ... m/s

(ii) Discuss whether or not this theoretical maximum velocity depends on the mass of the passengers. [2]

....

....

....

(iii) In practice, the car reaches a velocity of 37 m/s after this first fall. The length of track on the fall is 100 m. Use equations from page 2 to calculate the mean resistive force on the car. [3]

Mean resistive force = ... N

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Marking Scheme

1.

Question			Marking details	Mark
6.	(a)		If no external / outside force acts (1) the total momentum remains constant /stays the same / is conserved **or** momentum before [collison/explosion] equals momentum after (1)	2
	(b)	(i)	15 x 800 (1) = 12 000 [kg m/s] (1)	2
		(ii)	Subs 12 000 or **ecf** (1) subs 1 600 kg (1) ans = 7.5 [m/s] (1)	3
		(iii)	16 000 [N] (1) to the left (1) Award 2 marks for -16 000 **or** equal and opposite force	2
	(c)	(i)	0	1
		(ii)	equal and opposite momentum (1) so total momentum is zero (1) **Either mark can be awarded on its own but only award 2 marks if they are linked.** Award 1 mark only for momentum to the right cancels momentum to the left unless linked to 1 of the other marking points.	2
			Question total	**[12]**

2.

Question				Marking details	Marks
4.	(a)			Initially weight is greater than air resistance [so he accelerates] (1) as he goes faster air resistance increases (1) eventually the forces balance (1) **To award all 3 marks the third statement written down must be linked to one of the previous two statements.**	3
	(b)	(i)		Change in momentum = 118 × 373 (1) = 44014 [kg m/s] (1)	2
		(ii)		Resultant force = $\frac{44014}{42}$ (1) = 1048 [N] (1) **ecf** from (i) OR use of $F = ma$ = 118 × 8.9 (1) = 1 050 [N] (1)	2
		(iii)		W = 118 × 10 = 1 180 N (1) Air resistance = W – resultant force or 1 180 – 1 048 (1) = 132 [N] (1) **ecf** from (ii) & on weight N.B. **Answer mark awarded only** if correct sign present e.g. 118 – 1 048 (1) = - 930 [N]	3
	(c)			Air resistance force small (1) because in contact with small number of air particles [per second] / so need to go very quickly for air resistance to balance weight / so need to go very quickly to reach terminal velocity (1) **To award both marks both statements must be linked.**	2
				Question total	**[12]**

3.

Question Number		Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT								
	1	(a)	(i)		2	0.1×8 (1) 0.8 [kg m/s] (1)			
			(ii)		1	- 0.6 [kg m/s]			+0.6
			(iii)		1	Total momentum before collision = + 0.2 [kg m/s] (**ecf** from parts (i) &(ii) probably giving an answer of +1.4)			
			(iv)		1	Same answer as (iii)			
			(v)		2	$v_B = \frac{0.2}{0.2}$ 2 mark for the numerator (**ecf** from (iv)) 1 mark for the denominator (i.e. 0.2)	If no workings shown: Award 2 marks for an answer of 1 [m/s] Award 2 marks for an answer of 7 [m/s] when **ecf** applied		
		(b)	(i)		2	$t = \frac{(0-8)}{-160}$ 1 mark for the numerator of (0 - 8) **or** (8 - 0) 1 mark for the denominator of -160 **or** 160 respectively	If no workings shown: Award 2 marks for an answer of 0.05 Award 1 mark for an answer of -0.05		
			(ii)		2	Force = 1.6 [N] (1) To the left / opposite [direction to force applied to B] (1)	In the negative vector / velocity direction (for second mark) Accept = -1.6 [N] for both marks Award 1 mark for: force on A is equal and opposite / same size and opposite		Force is backwards / same size
		(c)			3	Before KE = $(\frac{1}{2} \times 0.1\ (8^2)) + (\frac{1}{2} \times 0.2\ (3^2)) = 3.2 + 0.9 = 4.1$ [J] (1) After KE = $0 + (\frac{1}{2} \times 0.2\ (1^2)) = 0.1$ [J] (1) **ecf** from (a)(v) KE lost = 4.1 – 0.1 = 4.0 [J](1) N.B. **ecf** from (a)(v) gives KE = $0 + (\frac{1}{2} \times 0.2\ (7^2)) = 4.9$ [J] and energy loss = -0.8 [J]	Award mark for correct subtraction where energies are wrong		Final answer of 0.8 from **ecfs** (Award 2 max for KE calculations)
		Total Mark			14				

4.

Question			Answer / Explanatory Notes	Marks Available
			Question total	**[6]**
4.	*(a)*		Initial K.E. = 0.5 x 1500 x 15^2 = 168 750 [J] (1) Final K.E. = 0.5 x 1500 x 5^2 = 18 750 [J] (1) Loss = 150 000 [J] (1) (award 1 mark for doing any subtraction but award no marks for use of $(15-5)^2$.)	3
	(b)		$F = \frac{150000(ecf)}{7.5}$ = 20 000 [N] (1) manip, (1) subst, (1) ans For candidates who present a momentum argument: $\frac{x}{t} = \frac{(u+v)}{2}$ to find time = 0.75 [s](1) momentum change = 15 000 [kg m/s](1) $F = \frac{15000(ecf)}{0.75(ecf)} =$ 20 000 [N] (1)	3
	(c)		F = 20 000 [N] ecf from *(b)*	1
			Question total	**[7]**

5.

Question			Marking details	Mark
5.	(a)	(i)	0.15 x 20 (1 for substitution) = 3 [kg m/s] (1)	2
		(ii)	$\frac{3}{0.5}$ (1) allow **ecf** from (i) = 6 [N] (1)	2
		(iii)	3 [N] allow **ecf** from (i) which gives the same answer as in (i) **or** allow **ecf** from (ii) which gives half the answer to (ii)	1
	(b)	(i) (ii)	e.g. car crash / emergency stop / sudden braking / landing on ground <u>Stretchy</u> seat belt / air bag / crumple zone to achieve it/ bending legs on landing **Mark parts (i) and (ii) together.**	2
			Question total	[7]

6.

Question			Marking details	Marks
3.	(a)	(i)	15 [m/s] (1)	1
		(ii)	900 [kg m/s] (1) **ecf**	1
		(iii)	$\frac{900(\text{ecf})}{6}$ = 150 (1) N **or** kg m/s^2 **or** Newtons (1)	2
	(b)		The same change in momentum happens in a short<u>er</u> time / change in momentum per second is great<u>er</u> / increased deceleration (1) so force increases / is great<u>er</u> (1) **The 2nd mark must be linked to the 1st mark.**	2
	(c)		**Any 2 × (1) from:** Air bag, crumple zone, head rest, passenger cage, ABS (anti-locking) brakes, <u>laminated</u> windscreen, collapsible steering-wheel / side impact bars / child safety seat **Do not accept** flexible bumper / crumble zone / crash zone / head support	2
			Question total	**[8]**

7.

Question			Marking details	Mark
3.	(a)		Object continues in its state of rest/inertia/motion/constant speed [in a straight line] (1) unless acted upon by an [external/unbalanced] force (1)	2
	(b)	(i)	2 250 x 8 (1 for substitution) = 18 000 [kg m/s](1) [Answer mark must be number on answer line]	2
		(ii)	(1 for subs + manip) $\frac{18000}{900}$ = 20 (allow **ecf** from (i)) final velocity = 20 (**ecf**) + 5 = 25 [m/s] (1) **OR** Final momentum = 4 500 + 18 000 = 22 500 (1) v = 25 [m/s] (1) **OR** Momentum ratio = velocity ratio e.g. 18 000:4 500 = 4 so arrive at a [change in] velocity of 20 [m/s] (1) v = 25 [m/s] (1)	2
			Question total	[6]

8.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	5	(a)	(i)		2	$P = VI = 120 \times 5$ (1) = 600 [W] (1)			
			(ii)		1	9 000 [J]	9 if k placed before J		9 kJ if given J not crossed out
			(iii)		2	GPE = $mgh = 50 \times 10 \times 14$ (1) = 7 000 [J] (1)			
			(iv)		1	Lost as heat / due to friction / energy to lift blocks and hook			Lost to atmosphere / energy wasted / energy lost / air resistance
		(b)	(i)		2	50 (1) $\times$ 10 = 500 [N] (1)	$F = \frac{W}{d}$ $= \frac{7\,000 (1)}{14}$ = 500 [N] (1)		$\frac{9\,000}{14}$ Substitution of 50 into the PE equation
			(ii)		2	Resultant / unbalanced force (1) so velocity increases / object accelerates (1) **The 2nd mark can only be awarded if it is linked to the 1st mark.**			Statements of Newton's laws Reference to air resistance
			(iii)		3	Change in GPE = gain in KE (1) KE = ½ mv^2 => $v^2 = \frac{2\text{KE}}{m}$ (1 rearranged) **ecf** from (a)(iii) $\frac{2 \times 7\,000}{50}$ = 280 [m^2/s^2] => v = 16.7 [m/s] (1)	Answer of 17 [m/s]		7 000 substituted into any equation other than an energy one
		Total Mark			13				

9.

Question			Marking details	Mark
6.	(a)		Indicative content: As the car is pulled to the top of the hill it gains potential energy. Since this is the highest point of its journey, this will be the maximum potential energy that the car will gain. As the car runs down the other side of the hill, potential energy will be converted to kinetic energy. As the car begins to rise at the next hill, the kinetic energy is then converted back into potential energy and so on. However due to resistive forces, some of the energy is dissipated as heat so during the ride the total energy possessed by the car decreases. This explains why each successive hill must be lower than the previous one. **5 – 6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3 – 4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1 – 2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.	6
	(b)	(i)	Calculation of PE using *mgh* or by implication (1): 1 200 x 10 x 90 (1) = [1 080 000 J] If 1 200 x 10 x 50 **or** 1 200 x 10 x 140 used this implies use of *mgh* so award 1 mark. 1 080 000 **ecf** = ½ mv^2 **or** 1 080 000 **ecf** = KE (1) = 600 v^2 v = 42.4 [m/s] **ecf** (1) **Alternatives**: If PE = KE stated anywhere award 1 mark If show ½ mv^2 = *mgh* anywhere award 2 marks	4
		(ii)	No (1), because ½ mv^2 = *mgh* **or** *m* cancels out (1) Actual KE at bottom = ½ 1 200 x 37^2 = 821 400 [J] (1)	2
		(iii)	Energy loss = 1 080 000 **ecf** – 821 400 **ecf** = 258 600 [J] (1) mean resistive force = WD **ecf** /distance = 2 586 [N] (1) **Question total**	3 **[15]**
			Higher Tier Paper Total	**[60]**