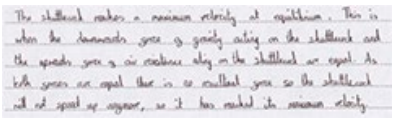
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			Any **three** from: As velocity /speed increases air resistance increases ✓ (until) the weight balances the air resistance ✓ No net / resultant force ✓ No acceleration (so no further increase in velocity)✓	3 (AO 1.2x3)	**ALLOW** drag for air resistance **ALLOW** equal / equilibrium **Examiner's Comments** There were many vague responses. For example, candidates often referred to the force upwards rather than air resistance or drag and the force downwards rather than weight. Many candidates also did not state that the drag increased with the speed at which the shuttlecock fell. More candidates used the technical terms weight or force due to gravity correctly rather than just referring to 'gravity.' Other common errors included 'as air resistance equals acceleration.' Exemplar 3  The candidate starts the answer by mentioning equilibrium, but does not explain at this stage what is in equilibrium. The answer then continues by naming the upwards and downwards forces correctly and stating clearly that these are equal, for 1 mark. The candidate then clearly states that the resultant force is zero, for the second mark. To have improved the answer, the candidate could have included that the air resistance was less than the weight initially so that the shuttlecock was accelerating. As the speed of the shuttlecock increased, the air

					resistance increased (until the weight the air resistance equalled the weight). The candidate could also have stated that since the result force was zero, there would be zero acceleration.
			Total	**3**	
2			D	1 (AO 1.1)	**Examiner's Comments** Candidates found this question challenging. All four options were commonly selected.
			Total	**1**	
3			D	1 (AO 1.1)	**Examiner's Comments** High-scoring candidates measured the distance of the arrows on the diagram, recording the values nextto each arrow to assist them in determining the largest net force. The majority of the candidates correctly identified option D. The common distractor was B.
			Total	**1**	
4		i	**First check the answer on the answer line** **If answer = 27 (m) award 3 marks** Select and rearrange: (distance =) final velocity^2 − initial velocity^2 ÷ 2 × acceleration **OR** (s =) $v^2 - u^2 \div 2 \times a$ ✓ Substitution: (s =) $-18^2 \div -12$ **OR** $18^2 \div 12$ **OR** 324 ÷ 12 ✓ (s =) 27 (m) ✓	3 (AO 1.2) (2 x AO 2.1)	**ALLOW** correct substitution into unrearranged equation for 1 mark e.g. $0 - 18^2 = 2 \times -6 \div s$ **OR** $18^2 - 0 = 2 \times 6 \times s$ **ALLOW** d for s **ALLOW** −27 (m) **ALLOW** other correct use of SUVAT equations of motion **Examiner's Comments** It was good to see that the majority of candidates could select the correct equation from the Equation Sheet and most gained 1 mark from substituting the values into the unrearranged equation. However, rearranging was

					again an issue, so something candidates need to practise.
		ii	**First check the answer on the answer line** **If answer = 2400 − 21 000 (N) award 3 marks** Estimation of mass of car = 1500 (kg) ✓ (F =) 1500 × 6 ✓ (F =) 9000 (N) ✓	3 (AO 1.1) (2 x AO 2.1)	**ALLOW** 2 marks for force correctly calculated if mass is outside of range **ALLOW** 400 − 3500 (kg) **ALLOW** candidate's mass estimate x 6 for 1 mark **ALLOW** candidate's mass estimate x 6 correctly calculated for 2 marks **<u>Examiner's Comments</u>** The vast majority of candidates scored at least 2 marks for substituting values into the equation and estimating the force acting on car B. However, estimates of the mass of the car varied a lot, with values of 6 kg to 600 000 kg seen. **Assessment for learning** Candidates could benefit from short activities where they estimate values of quantities such as the masses and speeds of objects.
		iii	**Any two from:** Skid mark may not have clear start or end ✓ Skid mark may be curved / difficult to measure ✓ (Idea that) car may not have produced a skid for whole of braking (distance) / **AW** ✓ (Idea that) skid mark only occurs when the wheels stop turning ✓	2 (2 × AO 3.2a)	**ALLOW** skid marks don't appear as soon as braking starts / deceleration is not always large enough to produce skids marks
			Total	**8**	
5		i	**First check the answer on answer line** **If answer = 28 500 (J) award 2**	2 (AO 2.1) (AO 2.1)	**ALLOW** 29 000 J (rounded to 2 significant figures)

			marks (E= mcθ) E = 0.50 × 1900 × 30 ✓ E = 28 500 (J) ✓		**ALLOW** 28.5 kJ **Examiner's Comments** This question was answered well. The majority of the candidates correctly determined the temperature change.
		ii	**First check the answer on answer line** **If answer = 95 (W) award 3 marks** P = E ÷ t ✓ P = 28 500 ÷ (5 × 60) ✓ P = 95 (W) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW 23(a)(i)** divided by 5 for 2 marks **ALLOW 23(a)(i)** divided by 300 for 3 marks **ALLOW ECF** from **23(a)(i)** **ALLOW** 5700 (W) for 2 marks (no unit conversion) **Examiner's Comments** This question was also answered well. A small minority of candidates did not change the five minutes to 300 seconds. Candidates should be encouraged to think about their calculated values. A power of 5700 W (not changing the time to seconds) is much larger than that of any domestic electrical appliance.
		iii	Containers of vaccines / other contents of the freezer need to be cooled ✓ Energy / heat dissipated / transferred to surroundings / environment or energy heat dissipated in motor / compressor ✓	2 (2 ×AO 3.2a)	**IGNORE** not 100% efficient **Examiner's Comments** Answers were generally vague and many candidates did not gain credit. Many candidates stated that the freezer was not 100% efficient but did not explain why. High scoring candidates often discussed that there was a container for each vaccine or that there were other contents in the freezer. Other candidates discussed the transfer of energy to/from the surroundings or heating in the motor. A common incorrect response was to

					state the specific heat capacity may be a different value.
			Total	**7**	
6			Correct resultant line drawn (connecting 0,0 and 6,4) ✓ Length of resultant line = 7.2 (cm) ✓ **But** Resultant force = 3.6 (N) ✓✓	3 (3 ×AO 1.2)	**Independent mark** **ALLOW ECF** for resultant drawn from (0,4) to (6,0) **ALLOW** 7.0 – 7.4 (cm) **IGNORE** '–' sign **ALLOW** 3.5 – 3.7 (N) **ALLOW** $(\sqrt{2^2+3^2}=)\,3.6$ for two marks **Examiner's Comments** Many candidates scored 2 marks for this question with many candidates drawing the incorrect resultant force. A common approach was to use Pythagoras theorem to determine the resultant; this gained credit. Other candidates correctly measured the resultant length and converted this to 3.6 N.
			Total	**3**	
7			**D**	1 (AO 2.1)	**Examiner's Comments** The majority of the candidates chose the correct response.
			Total	**1**	
8			**A**	1 (AO 1.2)	**Examiner's Comments** While the majority of the candidates gained a mark, a large number of candidates incorrectly thought that since the object is travelling at constant speed, it was not accelerating (Option D).
			Total	**1**	
9			**Level 3 (5–6 marks)** Detailed explanation of why car **A** is safer than car **B** **AND** good estimation of deceleration of car **A** / quantitative comparison of decelerations *There is a well-developed line of reasoning which is clear and logically*	6 (3 × AO2.1) (3 × AO1.1)	**AO2.1 Applies knowledge and understanding of scientific ideas to estimate acceleration** Estimation of acceleration using distance or time • car **B** has a higher/double acceleration • Use of $a = (v^2 - u^2)/2s$

			structured. The information presented is relevant and substantiated. **Level 2 (3–4 marks)** Detailed explanation of why car **A** is safer than car **B** **AND** an attempt at estimation/comparison of decelerations **OR** Good estimation of deceleration of car **A** / quantitative comparison of decelerations **AND** a basic explanation of why car **A** is safer than car **B** *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Basic explanation of why car **A** is safer than car **B** **OR** An attempt at estimation/comparison of decelerations *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit*		• a =(−)14^2 / 2 × (their value of distance) • Use of a = (v − u) / t • a = 14/ (their value of time) **AO1.1 – Demonstrates knowledge and understanding why car A is safer than car B** • (Smaller force) reduces risk of (serious) injury to driver/passengers Explanation • Increased stopping distance/time for car **A** means deceleration of car **A** is half/less than car **B** / **ORA** • Car **A** slows down over a longer distance/time • Smaller acceleration / smaller rate of change of momentum for car **A** / **ORA** • So force acting on car **A** is half/less than car **B** / **ORA** • Since F = ma / F= rate of change of momentum • Greater distance/time for (kinetic) energy to be dissipated • Since W = Fd / same KE transferred / same KE dissipated over a longer distance/time **<u>Examiner's Comments</u>** This was the Level of Response question, targeted up to Grade 9, and assessed AO1 and AO2. There was a wide range of marks achieved and the question discriminated very well. Very few candidates were not given any marks. The majority of candidates were able to give a description of why car A was safer in terms of force and/or injuries or attempted to estimate the deceleration, although the values they used for time or distance were often

					very unrealistic. Many candidates discussed crumple zones. More detailed responses required for Level 2 and 3 included linking deceleration or rate of change of momentum to force with a reference to relevant equations. Exemplar 2  This response achieved Level 3, 6 marks. The explanation is very detailed, using the equation to link more time for the momentum to change to less force. There is a good estimation of the deceleration using a correct equation from the Data Sheet and a realistic value for the time taken.
			Total	**6**	
10			Forces are equal ✓ Magnet is travelling at a constant speed / terminal velocity / magnet is not accelerating ✓	2 (2 × AO2.1)	**ALLOW** resultant force is zero **ALLOW** balanced **IGNORE** equilibrium **Examiner's Comments** Several candidates gave vague explanations. Careful measuring of the arrows indicate that the magnetic force was equal to the weight so that the resultant force on the magnet was zero. Having determined the resultant force acting on the magnet was zero, the magnet was travelling at constant speed downwards or at its terminal velocity.
			Total	**2**	
11	a	i	Equal / 30N ✓ Opposite (direction) ✓	2 (2 × AO1.1)	**IGNORE** backwards **Examiner's Comments**

					Many candidates scored both marks in this question. When only 1 mark was scored it was generally because candidates had not mentioned the direction.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = (−)0.6 (m/s^2) award 3 marks** a = F / m✓ m s 30 / 50✓ 0.6 (m / s^2) ✓	3 (AO1.2) (AO2.1) (AO2.1)	Correct rearrangement of equation Correct substitution of numbers **IGNORE** sign **ALLOW** one mark for 0.75 (incorrect mass) **Examiner's Comments** This question was answered well. High scoring candidates often showed their working. Candidates should show the rearrangement of the equation and the data correctly substituted.
	b	i	Zero / 0 (kgm/s)	1 (AO2.1)	**IGNORE** units **Examiner's Comments** This was well answered - some candidates showed the calculation others stated zero. Some low scoring candidates stated 90 (the combined mass).
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 80 (kg m / s) award 2 marks** = 40 × 2 = 80 (kg m / s)	2 (2 × AO2.1)	**IGNORE** sign **Examiner's Comments** This was very well answered. It is useful to see the method – the first mark was given for 80 × 2.
		iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = (-)1.6 award 3 marks** Momentum before = momentum after ✓ 80 = 50 V_B ✓ 1.6 (m/s) ✓	3 (AO1.2) (AO2.1) (AO2.1)	**ALLOW** ECF from (b)(ii) but not from (b)(i) **ALLOW** 0 = (40 × 2) + 50 V_B **or** 0 = 80 + 50 V_B **ALLOW** V_B = −80/50 **IGNORE** sign **Examiner's Comments** This was again very well answered by high scoring candidates. Common errors included the wrong value of

					mass or using a different value of momentum.
			Total	**11**	
12			C ✓	1 (AO2.1)	**Examiner's Comments** This was well answered by most candidates with many candidates choosing to use Pythagoras' theorem. A small minority of candidates did just add 40 and 60 to make 100 N.
			Total	**1**	
13			B ✓	1 (AO2.1)	**Examiner's Comments** In this question a small minority of candidates calculated the potential energy for one step. Candidates who scored a mark on this question often underlined the data used in the question.
			Total	**1**	