	Answers	Extra information	Mark	AO / Specification reference
01.1	<table><tr><th>Factor</th><th>Affects thinking distance</th><th>Affects braking distance</th></tr><tr><td>road conditions</td><td></td><td>✓</td></tr><tr><td>distractions in the car</td><td>✓</td><td></td></tr><tr><td>speed</td><td>✓</td><td>✓</td></tr></table>	one mark for each correct column	2	AO1 AO2 4.5.6.3.1 4.5.6.3.2 4.5.6.3.3
01.2	appropriate example e.g., tiredness if you are tired your reaction time is greater the thinking distance will increase	accept other examples e.g., drugs/alcohol	1 1 1	AO1 4.5.6.3.2
01.3	appropriate example e.g., icy road conditions will increase the braking distance the stopping distance = the thinking distance + the braking distance the stopping distance will increase		1 1 1	AO1 4.5.6.3.1 4.5.6.3.3
02.1	thinking distance = speed × reaction time = 13.4 × 0.67 = 8.978 m = 9.0 m	answer given to two significant figures	1 1	AO2 4.5.6.3.2
02.2	stopping distance = 13.9 m + 8.978 m = 22.878 m = 23 m	answer given to two significant figures	1 1	AO2 4.5.6.3.1

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02.3	thinking distance at 50 mph = thinking distance at 30 mph × $\frac{50}{30}$ = 9.00 × $\frac{50}{30}$ = 15 m the distance is proportional to the speed if the reaction time is constant	accept working out thinking distance using equation	1 1 1	AO2 AO3 4.5.6.3.1 4.5.6.3.2 4.5.6.3.3
02.4	braking distance = stopping distance - thinking distance (= 53.0 – 15) = 38 m		1 1	AO2 4.5.6.3.1 4.5.6.3.2 4.5.6.3.3
03.1	independent – type of surface dependent – distance it travels on the surface before stopping control – any two from: • height of ramp • position of release of trolley • type of trolley/mass of trolley	one mark for each correct point up to a maximum of two marks	1 1 2	AO2

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03.2	method e.g., • raise one end of the ramp by a height h • cover the floor at the other end of the ramp with a type of surface • place a trolley at the top of a ramp and releases it • measure the distance the trolley travels from the bottom of the ramp to the place that it stops • repeat the experiment twice more with the same surface • replace the surface with a different material and repeat the experiment with ramp at same height h • identify outliers; do not include them in the calculation of mean		max 5	AO1
03.3	appropriate example with improvement e.g., releasing the trolley from exactly the same place each time <u>improvement:</u> draw a line on the ramp and line up the back of the trolley with the line each time	**or** leaving ramp – make transition as smooth as possible by making sure the surface is at the same height as the bottom of the ramp	1 1	AO3
03.4	this is a good model because different surfaces will affect the stopping distance difference surfaces produce different frictional forces on the trolley, so do different amounts of work on it.		1 1 1	AO2 AO3 4.5.6.3.4
03.5	the investigation does not involve braking because the trolley does not have brakes	**or** no thinking distance can be included as no 'brain' in the trolley	1 1	AO3

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04.1	as distance increases, the reaction time increases at a decreasing rate / they are not directly proportional if you have a longer reaction time the ruler will fall further		1 1	AO2 AO3 4.5.6.3.2
04.2	0.23 s	accept 0.22 – 0.24	1	AO2 4.5.6.3.2
04.3	yes typical reaction times range from 0.2 – 0.9 s		1 1	AO1 AO2 4.5.6.3.2
04.4	appropriate example e.g., the partner holds the ruler a big distance above the student's hand the distance it falls will be larger than it should be the reaction time will be smaller than it actually is as they are no longer proportional		1 1 1	AO3 4.5.6.3.2
05.1	the data is checked by other scientists peer review		1 1	AO1
05.2	force is measured in newtons/kilograms or tonnes are both a unit of mass, not force		1	AO1 4.5.1.3
05.3	weight = mass × gravitational field strength	allow W = mg	1	AO1 4.5.1.3
05.4	W = 1000 × 9.8 = 9800 N		1 1	AO2 4.5.1.3
05.5	people (without a science background) reading the article may be able to relate better to tonnes than to newtons.		1	AO3

	Answers	Extra information	Mark	AO / Specification reference
05.6	momentum = mass × velocity acceleration = $\frac{\text{change in velocity}}{\text{time}}$ velocity = acceleration x time = 9.8 x 2.5 = 24.5 m/s momentum = 2.5 × 24.5 = 61.3 kg m/s	**or** Ft = mv-mu 2.5 x 9.8 x 2.5 = mv – 0 mv = 61.25 kg m/s	1 1 1 1	AO1 AO2
06.1	momentum = mass × velocity = 65 × 5 = 325 kg m/s		1 1 1	AO1 AO2 4.5.7.1
06.2	momentum is conserved the mass of the two skaters together after the collision is bigger than the mass of the single skater before the collision so the velocity of the two people together will be less than 5.0 m/s assuming the system is closed/there are no external forces acting		1 1 1 1	AO1 AO2 4.5.7.1
06.3	momentum before = momentum after 325 = (65 + 85) × velocity afterwards velocity afterwards = $\frac{325}{65+85}$ = 2.17/2.2 m/s		1 1 1	AO2 4.5.7.1
06.4	the barrier exerts an external force the system is not closed		1 1	AO1 AO2 4.5.7.1

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07.1	70 miles = 70 x 1609 m = 112 630m 1 hour = 3600s speed = $\frac{112630}{3600}$ = 31(.3) m/s		1 1 1	AO1 AO2 4.5.6.1.2
07.2	keep the cars far enough apart/a big distance apart so that the driver can brake in time/the distance is bigger than the stopping distance		1 1	AO3 4.5.6.3.1 4.5.6.3.2
07.3	thinking distance = stopping distance - braking distance = 96 - 75 = 21 m distance = speed × time 21 = 31.3 x time time = $\frac{21}{31.3}$ = 0.67s		1 1 1 1	AO1 AO2 4.5.6.3.1 4.5.6.3.2
07.4	the distance is half the stopping distance		1	AO3 4.5.6.3.1
07.5	correct suggestion e.g., the driver will start to brake when they see the brake lights of the car in front during that time the car in front is also coming to a stop **or** to see 2 chevrons, the cars need to be 3 chevrons apart so 120 m, not 80 m		1 1 **or** 1 1	AO3 4.5.6.3.1

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08.1	graph B in an emergency stop the driver presses the brake pedal harder/uses a bigger force producing a bigger deceleration at every speed the braking distance is shorter		1 1 1 1	AO2 AO3 4.5.6.3.3 4.5.6.3.4
08.2	appropriate suggestion e.g., internal organs can be damaged/the organs of your body continue to move	**or** extra friction on/damage to the tyres	1	AO2 4.5.6.3.4
08.3	no difference/it is the same at a particular speed thinking distance is related to reaction time, which is the same in both situations at the same speed		1 1	AO1 AO2 4.5.6.3.1 4.5.6.3.2
09.1	texting and conversation increase your reaction time conversation by up to 1.9 and texting by up to three times as long which increases your thinking distance/stopping distance causing more accidents		1 1 1	AO3 4.5.6.3.2
09.2	thinking distance = speed × reaction time with no phone: = 13.4 × 1.00 = 13.4 m complex conversation: = 13.4 × 1.80 = 24.12 m difference = 24.12 - 13.4 = 10.7 m		1 1 1	AO2 4.5.6.3.2

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09.3	24.12 m = speed × 1.00 s speed = $\frac{24.12}{1.00}$ = 24.12 m/s 24.12 × $\frac{30}{13.4}$ = 54 mph having a conversation has the effect of nearly doubling the effective speed of the car in terms of thinking distance.		1 1 1 1 1	AO2 AO3 4.5.6.3.2
10.1	force = spring constant × extension		1	AO1
10.2	extension = 1.25 - 1.00 = 0.25 m 100 = spring constant × 0.25 spring constant = $\frac{100}{0.25}$ = 400 N/m		1 1 1 1	AO2
10.3	H = L_2 + d = 1.25 + 0.5 = 1.75 m		1 1	AO3
11.1	maximum force with airbag = 800 N maximum force without airbag = 4750 N ratio of forces = $\frac{4750}{800}$ = 5.9 the force without an airbag is nearly 6 times the force with an air bag	readings from graph	1 1 1	AO2 AO3 4.5.7.3
11.2	estimate between 500 N and 800 N		1	AO3 4.5.7.3

	Answers	Extra information	Mark	AO / Specification reference
11.3	force = $\frac{\text{change in momentum}}{\text{time}}$ momentum = mass x velocity force = $\frac{\text{mass} \times \text{change in velocity}}{\text{time}}$ 750 ms = 750×10^{-3} s 750 = $\frac{60 \times \text{change in velocity}}{750 \times 10^{-3}}$ change in velocity = $\frac{750}{60} \times 750 \times 10^{-3}$ = 9.4 m/s final velocity = 0 m/s, so initial velocity = 9.4 m/s		1 1 1 1 1	AO1 AO2 4.5.7.3
11.4	the acceleration is less/change in velocity happens over a longer time the force required is much smaller for the same change in momentum		1 1	AO1 AO2 4.5.7.3
12.1	work is done by friction/energy transferred mechanically		1	AO1 4.5.6.3.4
12.2	the brakes/the surroundings		1	AO1 4.5.6.3.4

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12.3	deceleration = $\frac{\text{change in speed}}{\text{time taken}}$ = $\frac{20}{4.3}$ = 4.7 m/s^2 assuming the acceleration is constant the acceleration is probably not constant because the brakes do not exert a constant force		1 1 1 1 1	AO1 AO2 AO3 4.5.6.3.4
12.4	braking force = mass × deceleration = 1250 × 4.7 = 5875 (= 5900 N) this is similar to the forces exerted by car engines	accept F = ma	1 1 1	AO2 4.5.6.3.4
13.1	weight = mass × gravitational field strength = 1 × 9.8 = 9.8 N		1 1 1	AO1 AO2 4.5.1.3
13.2	work = force × distance = 9.8 N × 1 m = 9.8 J		1 1 1	AO1 AO2 4.5.2
13.3	9.8 N	allow error carried forward	1	AO2 4.5.1.3

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14.1	kinetic energy = 0.5 × mass × speed^2 = 0.5 × 1500 × 13.4^2 = 134 670 =1.35×10^5 J		 1 1 1	AO1 AO2 4.1.1.2
14.2	work done = force × distance 1.35 x 10^5 = 10000 × distance distance = $\frac{1.35\times10^5}{10000}$ = 13.5 m difference = 13.5 - 9.4 = 4.1 m		1 1 1 1 1	AO1 AO2 4.5.2 4.1.1.2
14.3	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance final velocity = $\sqrt{(2\times \text{acceleration}\times \text{distance})+(\text{initial velocity})^2}$ final velocity = $\sqrt{(2\times(-6.7)\times 9.4)+13.4^2}$ final velocity = 7.32 m/s = 7.32 × $\frac{3600}{1609}$ = 16.4 mph		 1 1 1 1 1	AO2 4.5.6.1.5
14.4	sensible suggestion with reason e.g., approach two because people can relate to the fact that the car will still be moving, so will cause injury to a person that they hit at that speed.		 1 1	AO3