Motion and Safety

Questions

Q1.

A car is travelling at 10 m/s.

The driver sees a danger and stops the car.

(i) The stopping distance for the car would be smaller if the car

(1)

- ☒ A had more passengers
- ☒ B had worn tyres
- ☒ C needed new brakes
- ☒ D was travelling more slowly

Figure 4 shows a speed-time graph for the driver stopping the car.

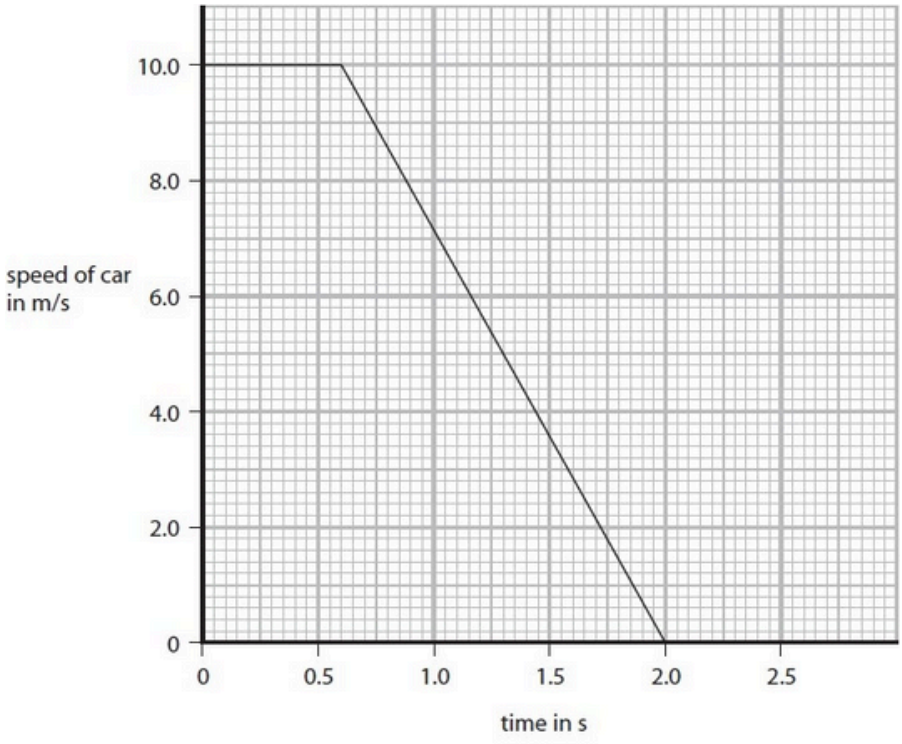


Figure 4

(ii) Use the graph to find the driver's reaction time.

(2)

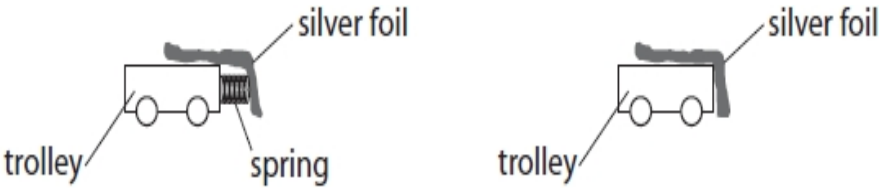
reaction time = ... s

(Total for question = 3 marks)

Q2.

A student investigates the effect of a crumple zone on the force exerted during a collision.

The student has one trolley with a spring at the front and another trolley without a spring.



The student uses the arrangement in Figure 13.

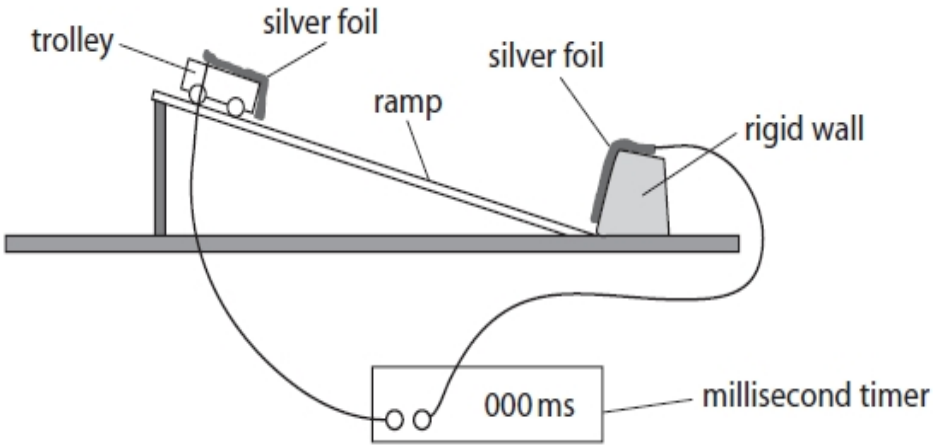


Figure 13

After a trolley is released, it accelerates down a slope and bounces off a rigid wall.

The speed of a trolley can be measured just before a collision with the wall and just after a collision with the wall.
The silver foils are connected to a millisecond timer.

The silver foils make contact with each other during the collision, so the time they are in contact can be read from the millisecond timer.
Explain how the student could investigate the effect of a crumple zone on the average force exerted during the collision.
Your explanation should include:

- how to determine the force (you may wish to refer to an equation from the list of equations at the end of this paper)
- how the effect of crumple zones may be shown in the investigation
- precautions that may be necessary to achieve accurate results.

(6)

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(Total for question = 6 marks)

Q3.

* Figure 13 shows two objects, Q and R, before and after they collide.

Figure 13

The arrows show the direction of movement of the objects.
The arrows are not to scale.
Explain how momentum is conserved in the collision.

Use Newton's third law and Newton's second law in your answer.

Newton's second law can be written as

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

(6)

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(Total for question = 6 marks)

Q4.

The graph in Figure 1 shows how the braking distance, d , of a car depends on the velocity, v, of the car when the brakes are first applied.

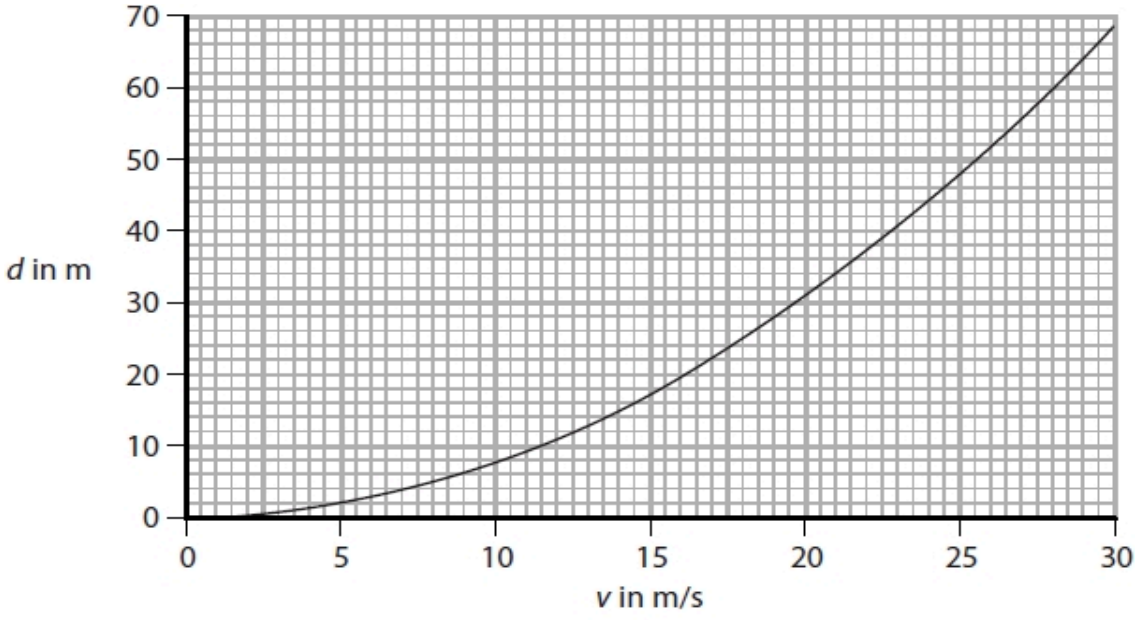


Figure 1

An equation relating braking distance, d, to velocity, v, is

$$d = \frac{v^2}{C}$$

where C is a constant.

Use the equation and data from the graph in Figure 1 to calculate a value for C.

Give a unit for C.

(4)

C =..... unit .....

(Total for question = 4 marks)

Q5.

The Asteroid Belt is part of our Solar System.

Vesta is an asteroid in the Asteroid Belt.

Vesta has an orbital speed of 1.9 × 104 m/s.

Vesta travels a distance of 2.2 × 1012 m when it orbits the Sun once.

Calculate the time taken for Vesta to orbit the Sun once.

(2)

time = ... s

(Total for question = 2 marks)

Q6.

A car travelling at 15 m/s comes to rest in a distance of 14 m when the brakes are applied.

Calculate the deceleration of the car.
Use an equation selected from the list of equations at the end of this paper.

(3)

deceleration = ... m/s2

(Total for question = 3 marks)

Q7.

The force that keeps an object moving in a circular path is known as the

(1)

- ☒ A balancing force
- ☒ B centripetal force
- ☒ C reaction force
- ☒ D resistance force

(Total for question = 1 mark)

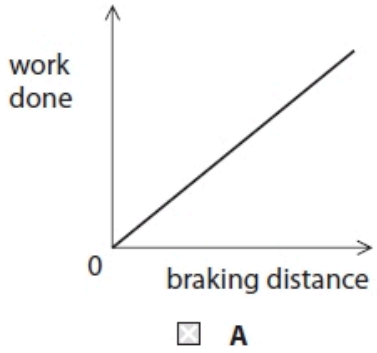
Q8.

The work done to bring a car to rest is given by the equation

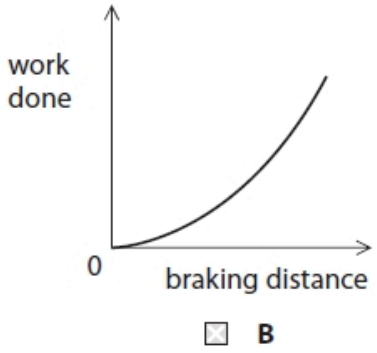
work done = braking force × braking distance

Which of these graphs is correct for the car if a constant braking force is applied?

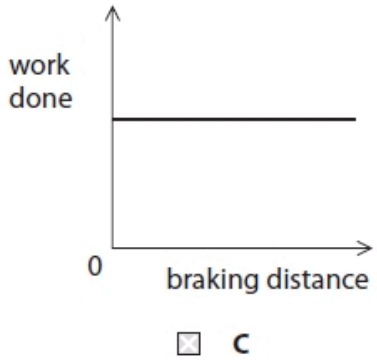
(1)



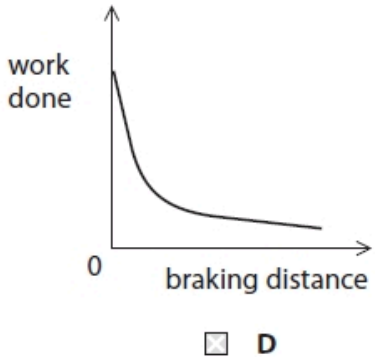
☒ A



☒ B



☒ C



☒ D

(Total for question = 1 mark)

Mark Scheme – Motion and Safety

Q1.

Question number	Answer	Additional guidance	Mark
(i)	D travelling more slowly A is incorrect, more passengers would increase the stopping distance B is incorrect, worn tyres would increase the stopping distance C is incorrect, if the car needed new brakes this would increase the stopping distance		(1) AO1

Question number	Answer	Additional guidance	Mark
(ii)	identification of horizontal line as reaction time (1) evaluation (1) 0.6 (s)	award full marks for correct answer without working 0.7 scores 1 mark	(2) AO3

Q2.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO2 (strand 2) (6 marks)** <u>Determining force</u> • Use of F = (mv - mu)/t or F =ma • mass (of trolley(s)) needed • and times during impact (t) <u>Showing effect of crumple zone</u> • experiment repeated with and without the spring • (note) difference in contact times • use of spring as crumple zone • with spring, time for contact greater, less impact force <u>Precautions or controls</u> • times repeated and average taken • careful controls – same starting position / same angle of slope / release without pushing etc.	**(6)Exp**

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• The explanation attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. • Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3-4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5-6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question. • Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

SUMMARY, for guidance			
Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Elements of physics present i.e. isolated knowledge of techniques and procedures – **two** unconnected statements from any section	Possible candidate responses Use F = (mv - mu)/t Use F = ma keep slope the same repeat and average use spring as crumple zone
Level 2	3–4	Additional guidance Some knowledge of techniques and procedures with a logical connection made in one section and statement from one more section	Possible candidate responses Measurements (difference in contact times) with and without the spring Use F = ma in finding the force
Level 3	5–6	Additional guidance Detailed knowledge of techniques and procedures with logical connections made in two sections and statement from one more section	Possible candidate responses Measure the trolley mass(es)/ velocities/ impact time(s) and use F = ma in finding the force Measurements (difference in contact times) with and without the spring Same starting place for trolley each time.

Q3.

Question Number	Answer	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • momentum = mass × velocity • action and reaction are equal and opposite (N 3) • force of R on Q = -force of Q on R • $\frac{\text{change in momentum of Q}}{\text{time}} = \frac{\text{- change in momentum of R}}{\text{time}}$ • time of collision same for both • change in momentum of Q = - change in momentum of R • no overall change in momentum • R accelerates because of force from Q • transfer of momentum between Q and R	**(6)** AO 1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• An explanation that demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• An explanation that demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• An explanation that demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q4.

Question Number	Answer	Additional guidance	Mark
	use values from graph (1) e.g. v = 20, d = 31 rearrangement (1) $C = \frac{v^2}{d}$ evaluation (1) (C=) 13 unit (1) m/s^2	accepting values to within one square allow numbers from 12.5 to 13.5 award 3 marks for the correct numerical answer without working independent mark	**(4)**

Q5.

	Answer	Additional guidance	Mark
	rearrangement and substitution (1) $(t =) \frac{2.2 (\times 10^{12})}{1.9 (\times 10^{4})}$ evaluation (1) 1.2×10^{8} (s)	 allow numbers that round to 1.2×10^{8} e.g. 1.1579×10^{8} award full marks for correct answer without working.	**(2)** **AO2**

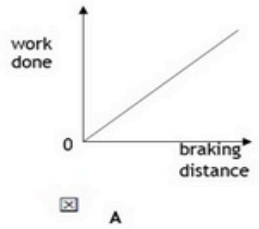
Q6.

Question Number	Answer	Additional guidance	Mark
	rearrangement (1) $a = \frac{(v^2-)u^2}{2x}$ substitution (1) $a = \frac{(-)15^2}{2 \times 14}$ evaluation (1) deceleration = 8(.04) (m/s^2)	rearrangement and substitution in either order 225/28 for 2 marks accept – 8(.04) award full marks for the correct answer with no working	**(3)** AO 2 1

Q7.

Question Number	Answer	Additional guidance	Mark
	☒ B centripetal force **The only correct answer is B (correct term for circular motion)** **A** is not correct – incorrect term **C** is not correct – incorrect term **D** is not correct – incorrect term		**(1)**

Q8.

Question Number	Answer	Mark
	 ☒ A **The only correct answer is A (showing direct proportionality)** **B** is not correct – curve (not showing direct proportionality) **C** is not correct – constant value shown (not showing direct proportionality) **D** is not correct – curve (not showing direct proportionality)	**(1)**