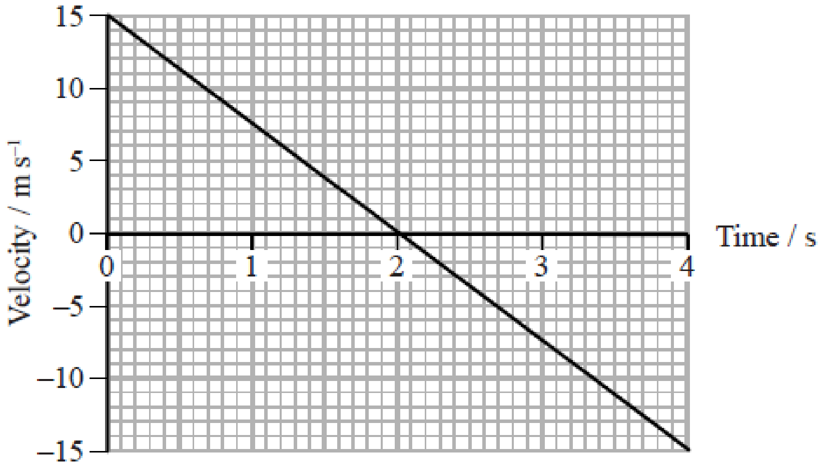
Questions

Q1.

A student throws a ball vertically upwards and catches it after 4 s. The student's data is used to plot a velocity-time graph for the ball.



Using the graph, what is the acceleration of the ball?

(1)

☐ **A** 7.5 m s^{-2}

☐ **B** −7.5 m s^{-2}

☐ **C** 3.8 m s^{-2}

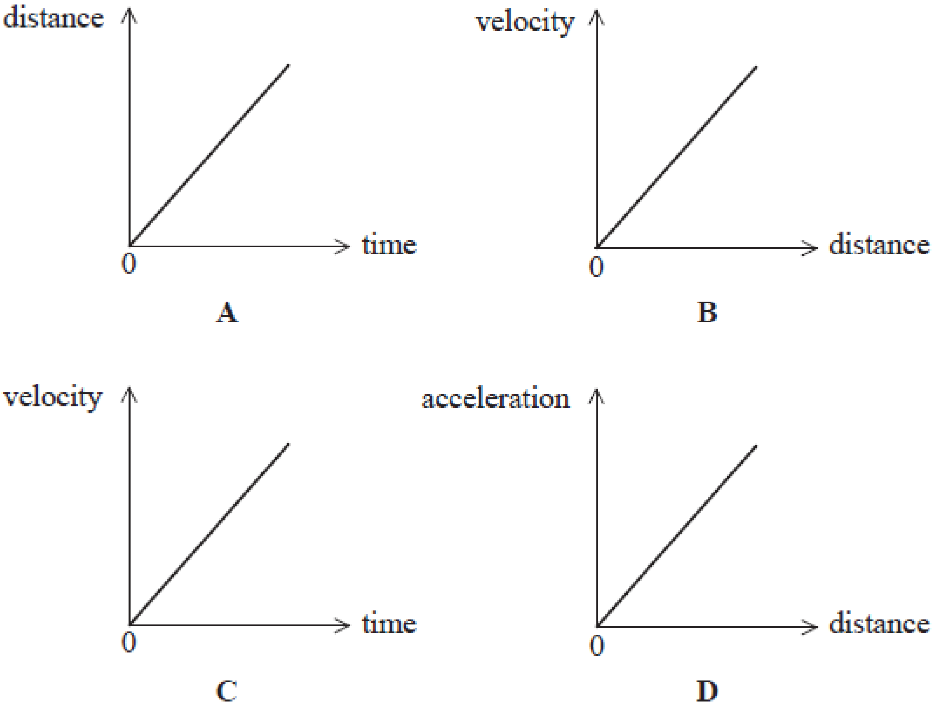
☐ **D** −3.8 m s^{-2}

(Total for question = 1 mark)

Q2.

A constant resultant force acts on an object.

Which of the following graphs is correct for the motion of the object?



(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for question = 1 mark)

Q3.

A car travels at a speed of 20 m s^{-1} due east and then turns around and travels at a speed of 40 m s^{-1} due west.

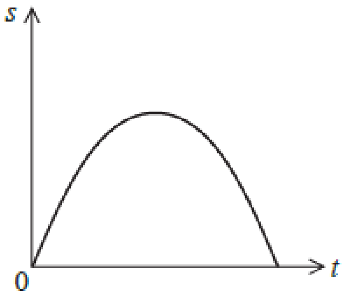
Taking the direction of due east as positive, select the correct row from the table.

	Change in speed / m s^{-1}	Change in velocity / m s^{-1}
☐ **A**	20	−60
☐ **B**	20	60
☐ **C**	60	−60
☐ **D**	60	60

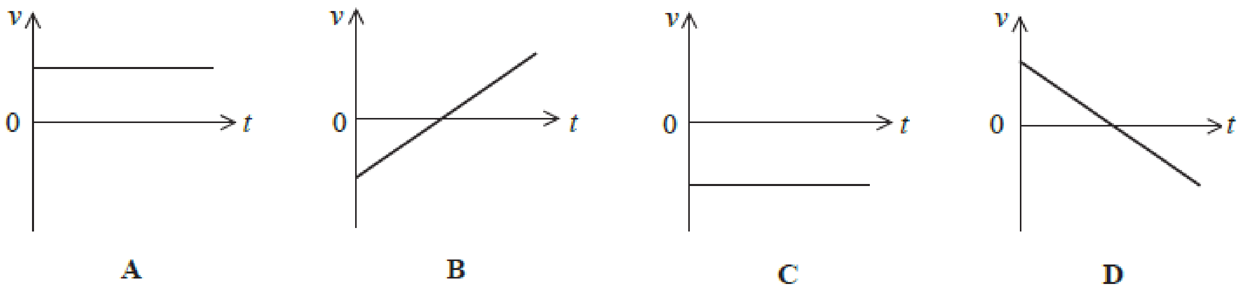
(Total for question = 1 mark)

Q4.

The displacement-time graph for an object is shown.



Which of the following is the corresponding velocity-time graph?



☐ **A**

☐ **B**

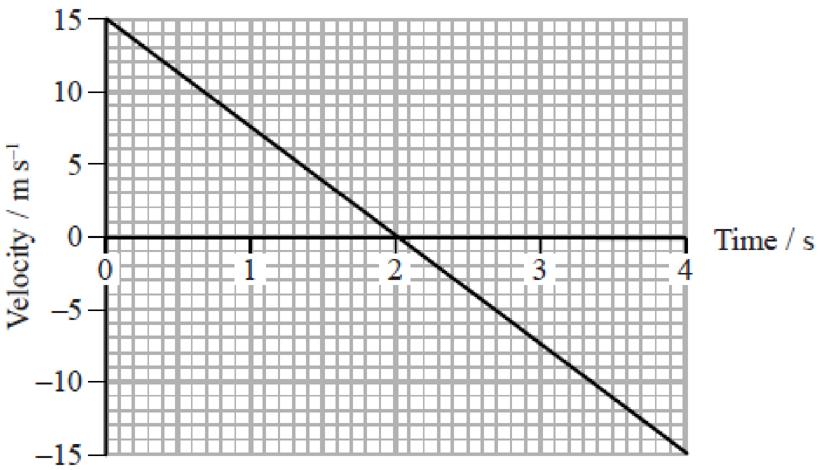
☐ **C**

☐ **D**

(Total for question = 1 mark)

Q5.

A student throws a ball vertically upwards and catches it after 4 s. The student's data is used to plot a velocity-time graph for the ball.



Using the graph, what is the total distance travelled by the ball?

(1)

- ☒ **A** 0 m
- ☒ **B** 15 m
- ☒ **C** 30 m
- ☒ **D** 60 m

(Total for question = 1 mark)

Q6.

In which of the following is a vector fully described?

- ☒ **A** A car travels north.
- ☒ **B** A crane moves a load 20 m east.
- ☒ **C** A train travels at a rate of 35 m s^{-1}.
- ☒ **D** A lift moves upwards with a kinetic energy of 2.5 kJ.

(Total for question = 1 mark)

Q7.

A football is kicked across a football pitch with an initial vertical component of velocity *u*. The ball lands back on the pitch after a time of flight *t*.

Which of the following equations can be used to determine *t*?

☒ **A** $\frac{u}{2g}$

☒ **B** $\frac{u}{g}$

☒ **C** $\frac{g}{u}$

☒ **D** $\frac{2u}{g}$

(Total for question = 1 mark)

Q8.

The gravitational field strength on Jupiter is 2.6 times greater than the gravitational field strength on Earth.

The weight of 10 kg of matter on Jupiter would be approximately

☒ **A** 26 N

☒ **B** 38 N

☒ **C** 98 N

☒ **D** 260 N

(Total for question = 1 mark)

Q9.

Physical quantities are either vectors or scalars.

Select the row of the table which correctly identifies vector and scalar quantities.

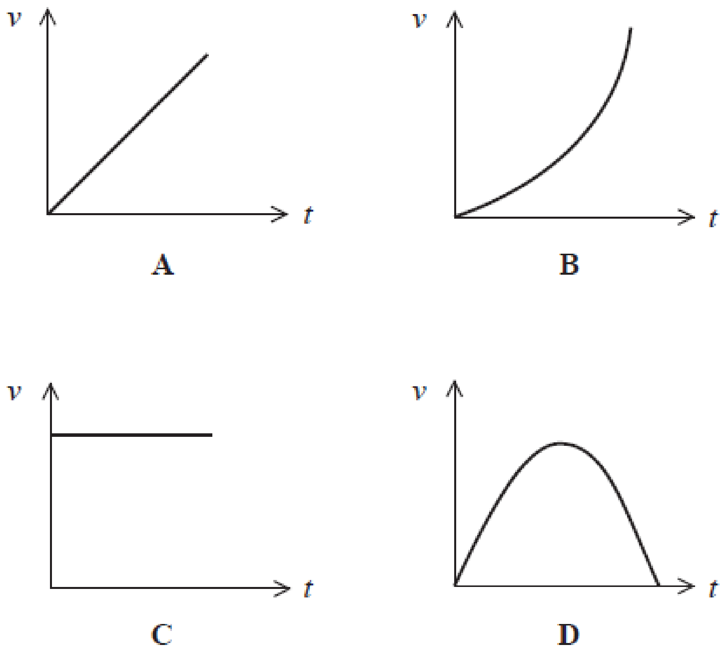
	Mass	Velocity	Displacement
☒ **A**	scalar	vector	scalar
☒ **B**	vector	scalar	vector
☒ **C**	vector	scalar	scalar
☒ **D**	scalar	vector	vector

(Total for question = 1 mark)

Q10.

A moving object has uniform, non-zero acceleration.

Which velocity-time graph correctly shows this?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q11.

Physical quantities are either scalars or vectors.

Select the row of the table which correctly identifies a scalar quantity and a vector quantity.

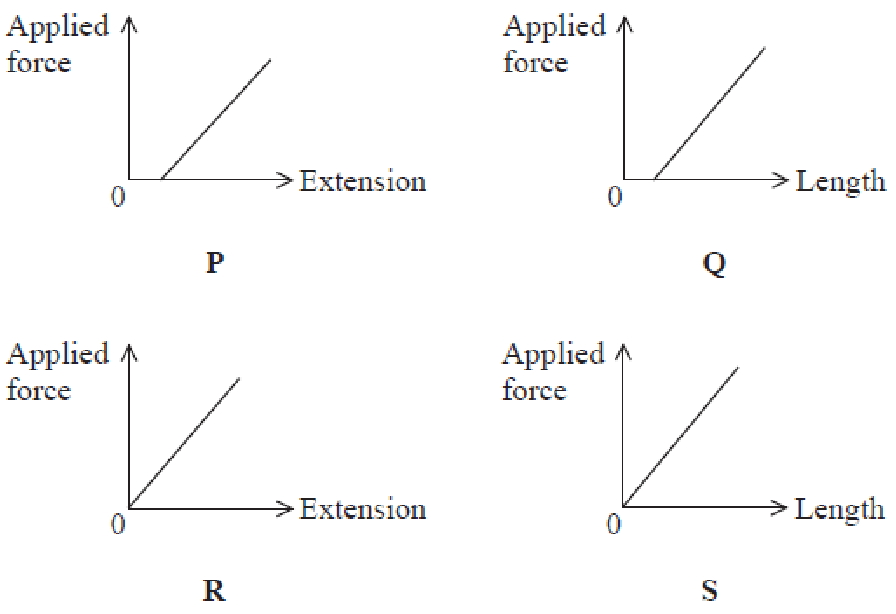
	Scalar	Vector
☒ **A**	force	velocity
☒ **B**	mass	time
☒ **C**	time	force
☒ **D**	velocity	mass

(Total for question = 1 mark)

Q12.

A force is applied to a spring and the spring extends. The new length of the spring is recorded.

This procedure is repeated for different applied forces.



The graphs could show that the spring is

(1)

- ☒ **A** obeying Hooke's law.
- ☒ **B** extending plastically.
- ☒ **C** extended beyond the limit of proportionality.
- ☒ **D** being compressed as well as extended.

(Total for question = 1 mark)

Q13.

(a) A student investigated the motion of a small sphere falling through oil.

The sphere was released at the top of a cylinder containing oil and measurements were taken to enable the terminal velocity of the sphere to be determined.

Describe the apparatus the student should use and the measurements to be taken. The student does not have access to a motion sensor or a data logger. You may include a labelled diagram in your answer.

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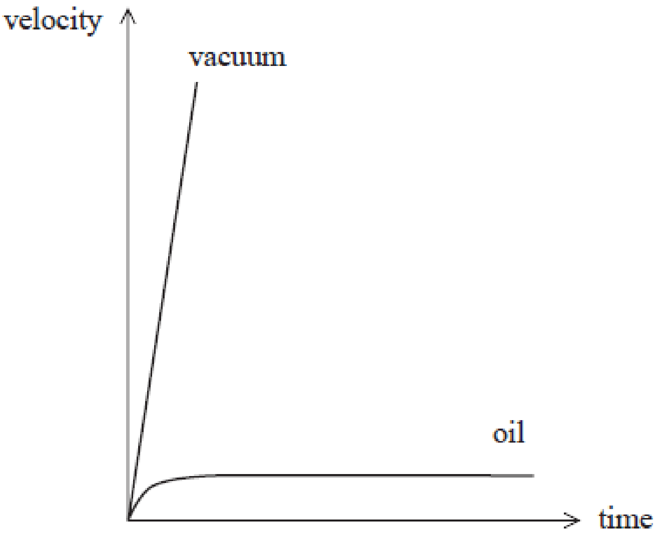
* (b) A teacher demonstrated the motion of a small sphere falling through a vacuum and

through oil.

The teacher used a motion sensor and data logger connected to a computer.
The computer plotted graphs of velocity against time for the sphere as shown.



Explain the differences between the shapes of the graphs.

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(Total for question = 11 marks)

Q14.

A marble is dropped from the roof of a building and takes 3.2 s to reach the ground.

The approximate height of the building is

☒ **A** 16 m

☒ **B** 31 m

☒ **C** 50 m

☒ **D** 100 m

(Total for question = 1 mark)

Q15.

A stone dropped into a well takes 1.5 seconds to reach the water.

Ignoring the effects of air resistance, what distance did the stone fall through?

☒ **A** 7 m

☒ **B** 11 m

☒ **C** 14 m

☒ **D** 22 m

(Total for question = 1 mark)

Q16.

Which of the following is a vector quantity?

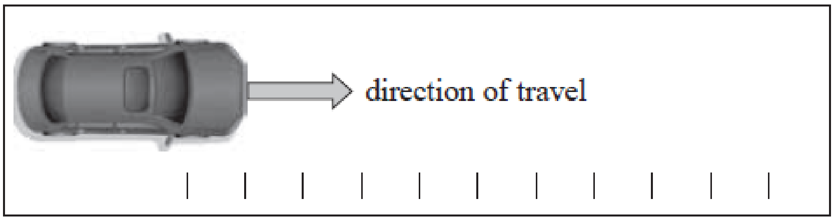
(1)

- ☒ **A** distance
- ☒ **B** speed
- ☒ **C** velocity
- ☒ **D** work done

(Total for question = 1 mark)

Q17.

A camera may be used to determine if a car is exceeding the speed limit. The camera takes two photographs, at a time interval of 0.50 s, as the car travels over a set of equally spaced road markings as shown.



Measurements from the photographs enable the speed of the car to be calculated.

(a) Explain why the speed calculated is an average speed.

(2)

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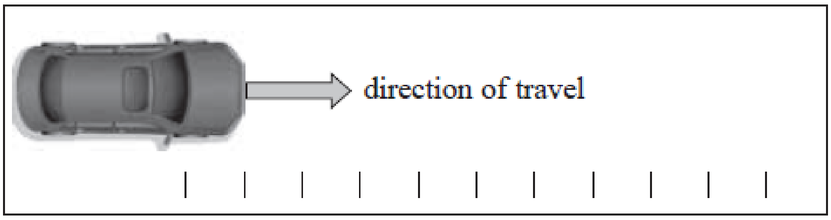
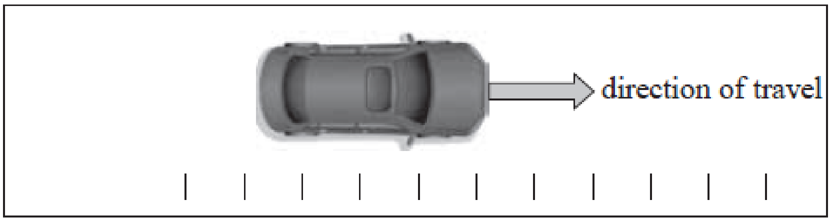
(b) The diagrams below show the positions of a car at a time interval of 0.50 s.

The markings are painted on the road at intervals of 1.52 m.



$t = 0$ s



$t = 0.50$ s

The speed limit is 50 km per hour.

Determine, using information from the diagrams, whether the car was exceeding the speed limit.

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(c) The position of the camera may result in an error in the calculated speed. Suggest why.

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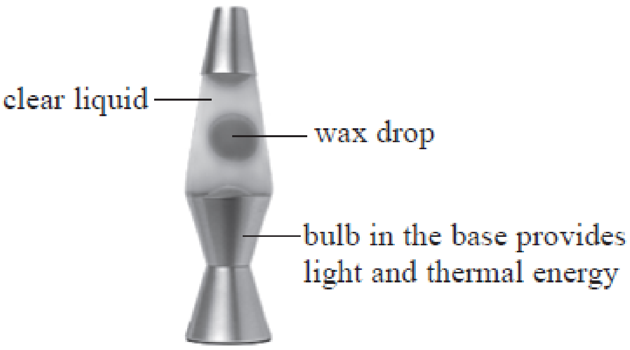
(Total for question = 7 marks)

Q18.

The photograph shows a 'lava lamp'.



When the lamp is switched on, large drops of liquid wax are seen to rise and then fall within the clear liquid.

(a) As a wax drop is heated it expands, its density decreases and it rises through the clear liquid.

(i) Explain why the wax drop begins to move upwards as it is heated.

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(ii) The wax drop accelerates initially and then reaches a terminal velocity.

Write a word equation for the forces acting on the wax drop when it is moving upwards at its terminal velocity.

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(b) The wax drop is seen to slow down as it reaches the top of the lamp.

Explain this observation.

(3)

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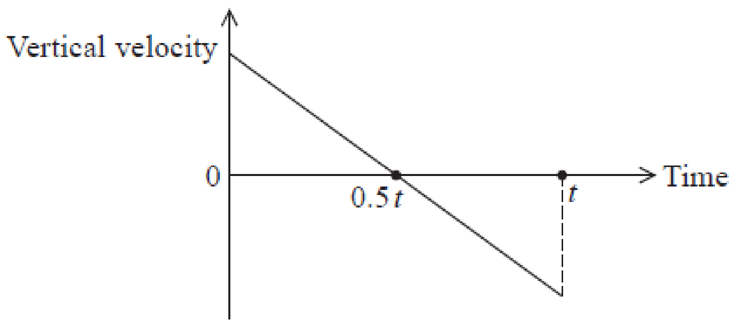
(Total for question = 8 marks)

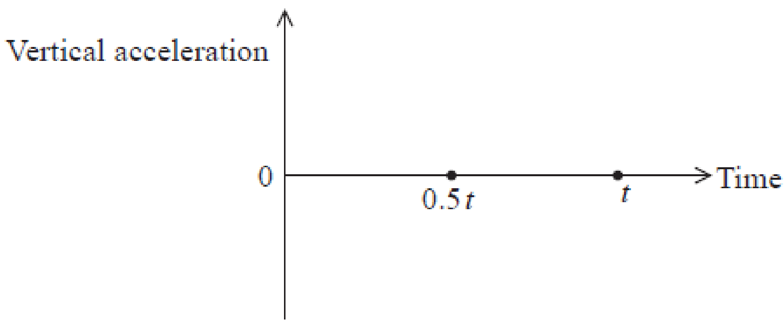
Q19.

A cricket ball is hit and travels across a field where it is caught at a time *t*. A graph of vertical velocity against time is shown.



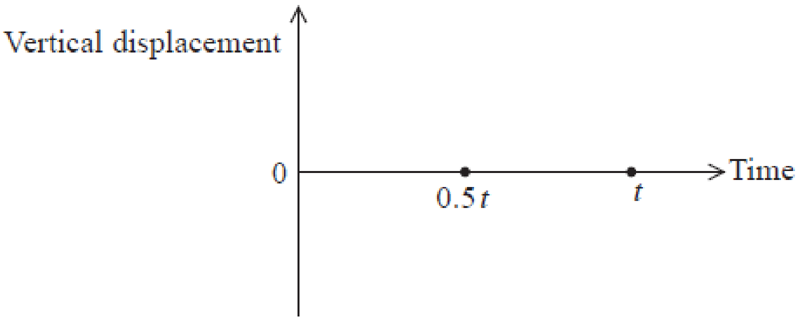
(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)



(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)

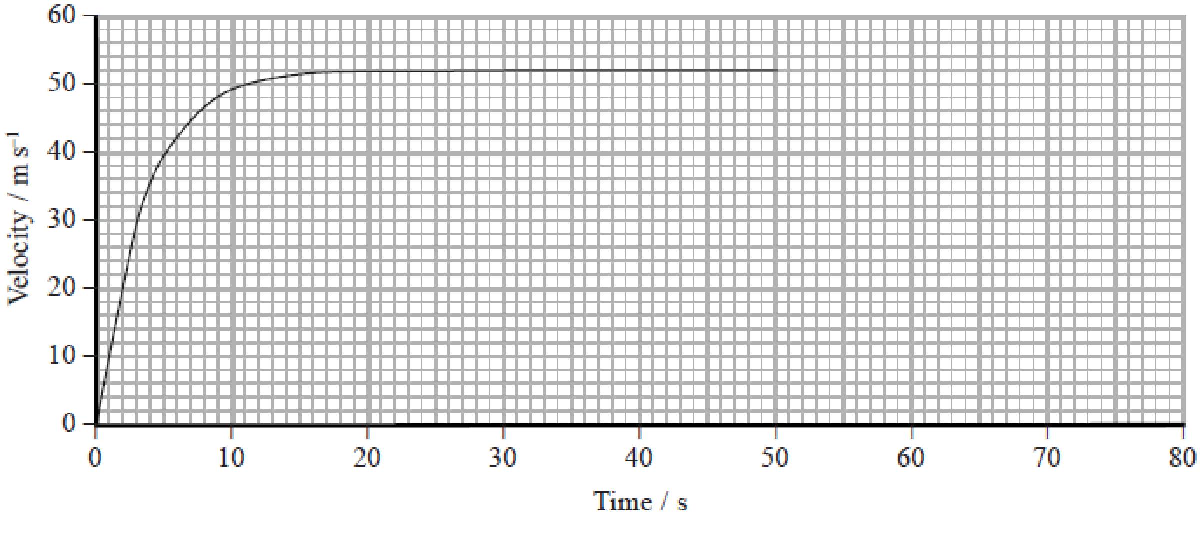


(Total for question = 4 marks)

Q20.

A skydiver jumped out of a plane and fell for 50 s before opening his parachute.

The graph shows how the skydiver's velocity varied with time over the first 50 s of his jump.



*(a) Explain the shape of the graph.

(4)

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(b) Sketch, on the graph above, the motion of the skydiver after he opens his parachute.

(2)

(c) (i) Explain the effect of the mass of the skydiver on the terminal velocity reached before he opened his parachute.

(2)

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(ii) Explain how the skydiver could decrease this terminal velocity as he falls.

(2)

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(d) The skydiver's jump was being filmed by another skydiver. Both skydivers jumped out of the plane at the same time. During the period of filming only the skydiver who was being recorded opened his parachute.

When viewing the recording after the jump, it appeared as though the skydiver being filmed moved upwards as he opened his parachute.

Explain this apparent movement.

(2)

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(Total for question = 12 marks)

Q21.

A ball is dropped and reaches the ground after 0.42 s. The ball bounces and is caught at the same height from which it was dropped.

Draw, on the graph paper below, the velocity-time graph for the motion of the ball. You may assume that the time the collision with the ground takes and all frictional forces are negligible. Show your working in the space provided.

(5)

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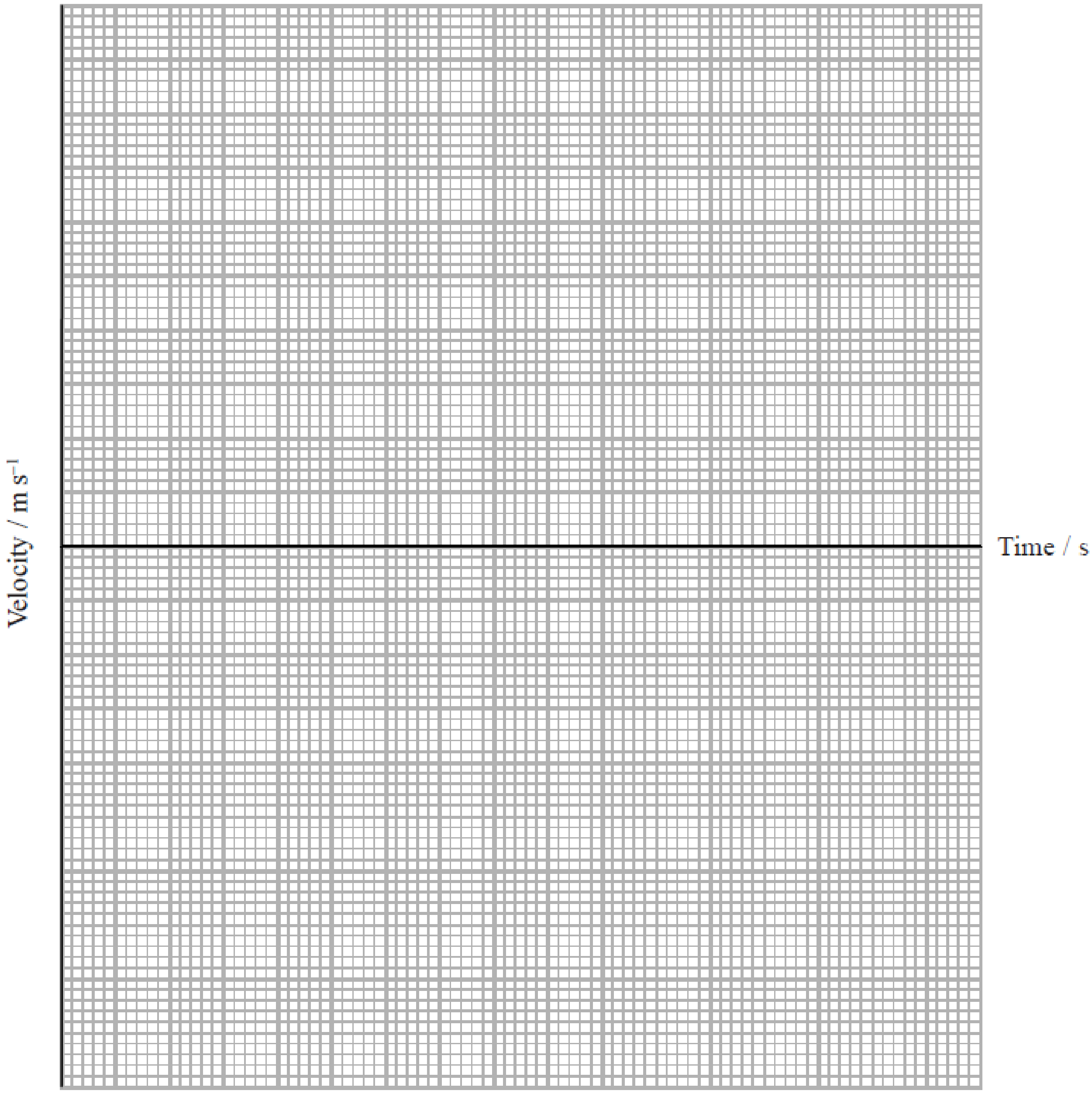


(Total for question = 5 marks)

Examiner's Report

Q1.

Question	Subject	% correct	Correct response	Most common alternative
	Velocity-time graph	73%	B	A

This question concerned a velocity time graph for a ball thrown in the air. Most candidates were able to calculate the acceleration of the ball from the graph's gradient, although many ignored the negative sign. They found determining the distance from the area under the graph far more demanding: many just calculated distance as velocity × time even though the velocity was changing.

Q2.

Question	Subject	% correct	Correct response	Most common alternative
	F=ma	60%	C	A

This question required rather more thought, that a constant force results in a velocity that increases uniformly with time. A large minority chose the response that showed the distance moved increasing uniformly, i.e. the constant velocity.

Q3.

This question concerned the vector nature of velocity, and was reasonably well answered. The main difficulty was deciding whether a change from 20 to −40 was +60 or −60.

Q4. No Examiner's Report available for this question

Q5.

Question	Subject	% correct	Correct response	Most common alternative
	Velocity-time graph	59%	C	D

This question concerned a velocity time graph for a ball thrown in the air. Most candidates were able to calculate the acceleration of the ball from the graph's gradient, although many ignored the negative sign. They found determining the distance from the area under the graph far more demanding: many just calculated distance as velocity × time even though the velocity was changing.

Q6.

Subject	Percentage of candidates who answered correctly	Most common incorrect response
Vectors	64	D

This is an example where candidates were rushing through a question. The most common incorrect response was 'D'. Asked independently of this question most candidates would identify the kinetic energy is not a vector quantity but at speed they just looked at the mention of 'upwards' and did not read on; clearly missing response A and response B's references to north and east as valid directions.

Q7.

This question discriminated well, with 51% giving the correct response, and the C+ candidates being the ones who responded correctly. The lower ability candidates either lost the factor of 2 (due to the ball rising and then falling) or put that factor in as ½ rather than 2.

Q8. No Examiner's Report available for this question

Q9. No Examiner's Report available for this question

Q10.

A straight-forward question to begin the paper with. Given that the most popular incorrect response was C this indicates that some candidates read through the text of the question too quickly, missing the key statement that the acceleration was non-zero. This was true across all abilities and not just at the lower end.

Q11.

Virtually all students at the top of the ability range scored this mark. However, a small number of students that answered this question incorrectly, most likely did so due to rushing and not giving the first question on the paper the time it deserves. Papers are generally ramped in that the difficulty increases as the questions progress through each section however, as is often seen, the first question often scores poorly for this reason.

Q12. No Examiner's Report available for this question

Q13.

(a)

There were 5 marks for this question:

Mark 1 was for a tall container of oil, usually on a diagram, with the top of the oil shown.

Mark 2 was for two markers between which the fall of sphere was timed, often two rubber bands around the cylinder. The markers had to be away from the top and bottom of the oil, to allow the sphere to reach terminal velocity, and enable accurate determination of that velocity.

Mark 3 was for measuring the distance fallen with a metre rule or ruler. The word "calculate" was not allowed for "measure" as no calculation was involved at this point.

Mark 4 was for measuring the time for the sphere to fall between the markers, using a stopwatch or timer. For these marks, the stopwatch or metre rule need not be specifically referred to if listed in an apparatus list or labelled on a diagram. A few responses referred to the time of fall from when the sphere was dropped, which was clearly incorrect as it was not all at the terminal velocity.

Mark 5 was for a reference to repeating the measurements, particularly the time, and this mark was not often awarded.

For a very straightforward experiment, it was disappointing to see the difficulty the candidates had in describing it. This question was not about determining the viscosity of the oil, but many candidates went into great detail about how the mass and diameter of the sphere would be determined, and gave the equation into which they would be substituted. The question is clearly just about determining the terminal velocity of the sphere, and anything further will gain no credit but could take a lot of time.

In addition, the question only asks for the apparatus and the measurements. It does not ask how the measurements would be used, so it was not required to describe the calculation of the terminal velocity, as many did, often using a graph.

Good candidates were able to give a clear, labelled diagram, without unnecessary apparatus, and wrote concise and clear statements about the measurements to be made.

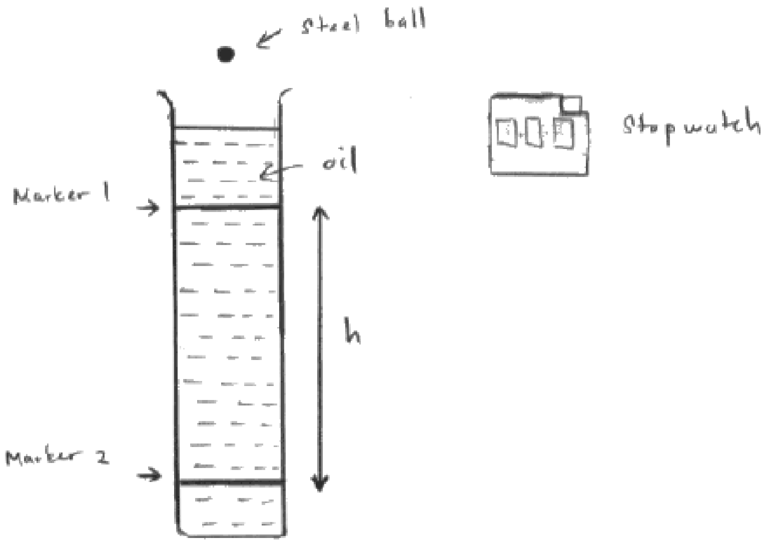
This first sample gets all 5 marks.

(a) A student investigated the motion of a small sphere falling through oil.

The sphere was released at the top of a cylinder containing oil and measurements were taken to enable the terminal velocity of the sphere to be determined.

Describe the apparatus the student should use and the measurements to be taken. The student does **not** have access to a motion sensor or a data logger. You may include a labelled diagram in your answer.

(5)



1. The diameter of the steel ball is measured using a micrometer screw gauge for a few times ~~at~~ in several different ~~on~~ orientation and the average is taken.
2. The ~~ste~~ height between marker 1 and marker 2 is ~~ca~~ measured using a metre rule.
3. The steel ball is gently dropped from the top of the measuring cylinder
4. The stopwatch is started immediately once the steel ball passes through the first marker and stopped once it passes through the second marker.
5. Terminal velocity = $\frac{\text{distance travelled}}{\text{time taken}}$
6. Experiment is repeated and results are averaged out.

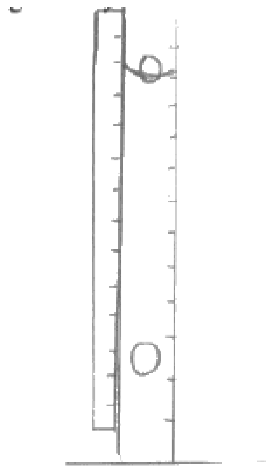
Results Plus: Examiner Comments

This diagram is drawn carefully, with a ruler, and is fully labelled, including an indication of the top surface of the oil – important when deciding where the top marker should be. The numbered steps in the written response make the method absolutely clear. The only problem is the inclusion of step 1, the measurement of the diameter, which is unnecessary.

Results Plus: Examiner Tip

If you draw a carefully labelled diagram, it often not only gains you marks but also focuses your mind on the method to be used.

This response gained one mark only for measuring the distance.



(5)

we many use a meter rule to measure the distance that the ball has fallen down
use a stopwatch to measure the time taken to reach the terminal velocity
a long cylinder is also needed to enables the ball to reach the terminal velocity.
~~use~~ use a small and dense ball to decrease drag

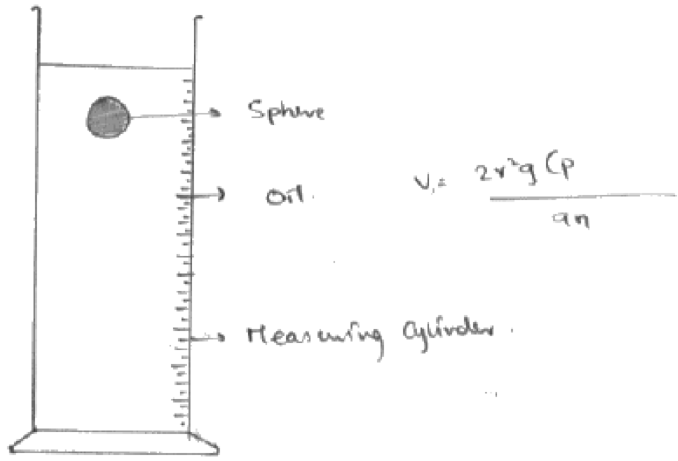
Results Plus: Examiner Comments

The diagram is somewhat carelessly drawn, and not labelled. There are no markers shown - the graduations are not sufficient. The time measured is the time to reach terminal velocity, so is incorrect. This candidate seems to have a reasonable understanding of the method, but an unclear drawing and lack of detail in the method have lost the marks.

Results Plus: Examiner Tip

Label diagrams.

This response gained a single mark for the diagram.



The student must use a micrometer screw gague to measure the radius of the sphere and an electric balance to record the mass. The density can be calculated $\rho_s = \frac{m}{v}$.
Volume of the oil can be recorded using the measuring cylinder.
Oil of known viscocity must be used. Using the balance first record the mass of empty cylinder and then cylinder with oil. Subtract the two to find mass of the oil.
Work out the density of the oil using $\rho_f = \frac{m}{v}$.
Find the velocity using $v = \frac{2\pi r^2 g(\rho_s - \rho_f)}{9\eta}$
Repeat the reading and take average for a reliable result.

Results Plus: Examiner Comments

This response occurred rather too often. Rather than the simple calculation of terminal velocity, this method requires the density of the oil and its viscosity to be known, along with the complex equation for terminal velocity. This equation would normally be used when determining the viscosity of a liquid, or when calculating the terminal velocity without doing an experiment, so the method was not allowed for this question.

(b)

There were 6 marks for this question, 2 for the graph for a vacuum and 4 for the graph for oil.

Mark 1 was for stating that the vacuum graph showed a constant acceleration. That was often done by saying that the acceleration was g, or 9.8ms^{-1}, but it was not sufficient just to describe the graph by saying the line was straight. This mark was commonly gained.

Mark 2 was for the reason that the acceleration was constant, and it was clear that the physics of free fall was not well understood. Few were able to say that in free fall, weight is the only force acting. It was not sufficient to say that there was no drag or no upthrust; we were looking for the positive statement about the weight. It was surprising how many candidates seemed to think that the viscosity of a vacuum was significant, just rather less than of the oil.

Mark 3 was for the implication that in the oil there was both upthrust and drag. This did not have to be an explicit statement, and often was picked up when mark 5 was being checked.

Mark 4 was for a statement that the viscous drag increases as the speed increases. It was not sufficient to say, as many did, that the viscous drag increases with time, although it clearly does. Such a statement does not explain what is happening, and the question asks the candidate to "explain". A few said that the viscosity increased with velocity, clearly incorrect.

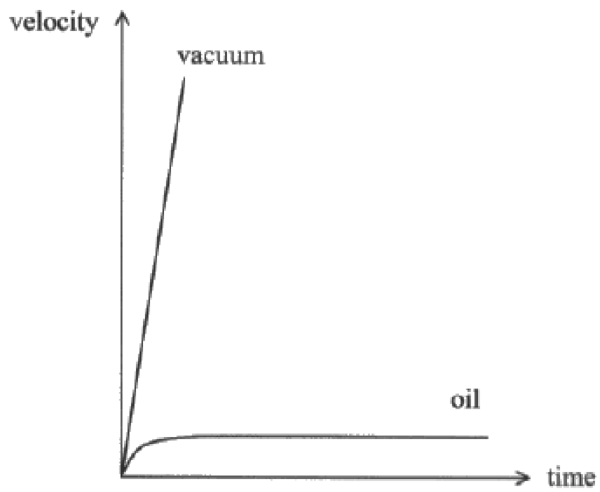
Mark 5 was for saying that the resultant force becomes zero (at the terminal velocity). This was often expressed in a form such as upthrust + drag = weight, which would also gain mark 3.

Mark 6 was for describing the terminal velocity. We were hoping that they would say that when terminal velocity is reached the velocity becomes constant or the acceleration becomes zero, but many neglected to mention terminal velocity.

This excellent response scored all 6 marks.

*(b) A teacher demonstrated the motion of a small sphere falling through a vacuum and through oil.

The teacher used a motion sensor and data logger connected to a computer. The computer plotted graphs of velocity against time for the sphere as shown.



Explain the differences between the shapes of the graphs.

(6)

When the sphere is ~~droped~~ dropped in vaccum it ~~mo~~ falls with constant accelerstion and the acceleration won't change as shown in graph, constant gradient of velocity vs time graph for vaccum, this is because the only weight acting on the sphere is it's weight (mass × g) thus there is no air to provide upthrust nor drag force. When sphere is dropped through oil at first ~~up~~ weight of sphere is greater than upthrust therefore it sinks but as it's velocity increases the drag force opposing the motion also increases due to viscocity of the liquid. Thus at one point Upthrust + drag force = weight of the sphere. The resultant force is zero ∴ sphere travells in constant speed reaching terminal velocity.

Results Plus: Examiner Comments

This candidate clearly does understand the physics of free fall, and explains the vacuum graph well. The existence of upthrust and drag when falling through the oil is well described, as is the reason for reaching terminal velocity.

Q14.

Subject	Percentage of candidates who answered correctly	Most common incorrect response
Use of equations of motion	85	B

Q15.

With calculation questions using the suvat equations, the direction of acceleration is often forgotten or sometimes even fiddled without full understanding. With this in mind this question set out to examine a candidate's understanding of vector direction for a simple projectile. The direction of either was not defined but a knowledge that the direction of the resultant force is downwards should have led candidates to the direction of the consequent acceleration and given that the ball is moving upwards, its velocity is in that direction.

Q16.

Question	Subject	% correct	Correct response	Most common alternative
	Vectors	94%	C	

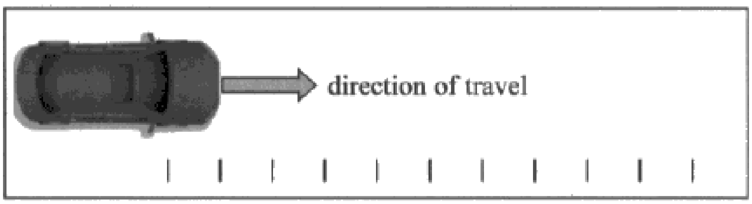
Q17.

(a)

There were two marks for this item: one mark for stating that the speed was an average because a total distance and time were used so that the speed was not an instantaneous one; the second for pointing out that the speed could be varying over the 0.5 s of the measurement.

Candidates were not very precise with their explanations, often commenting on an average being the mean of several readings, or that it was an average because it was not an instantaneous reading. Most candidates either gained a mark by commenting on the measurement method (total distance), or by commenting on the changing speed, but rarely gave both statements. Any description of the changing speed would be sufficient to gain the second mark, and we often saw comments that the car was accelerating or decelerating, both of which are good explanations for it being an average speed measured.

A camera may be used to determine if a car is exceeding the speed limit. The camera takes two photographs, at a time interval of 0.50 s, as the car travels over a set of equally spaced road markings as shown.



Measurements from the photographs enable the speed of the car to be calculated.

(a) Explain why the speed calculated is an average speed.

(2)

it is calculated by the equation $\frac{\text{total distance}}{\text{total time}}$ (~~displacement~~) however speed may have not been constant throughout the travelled distance.

Results Plus: Examiner Comments

This good response gained both marks.

The candidate has clearly stated that total distance has been used in the calculation, and that the speed could be varying.

This response gained 1 mark.

Because average speed = $\frac{\text{total distance}}{\text{total time}}$. It has fixed distance and use 0.5s. So it's an average speed

Results Plus: Examiner Comments

There is no mention here that the speed could be changing. The fact that there are 2 marks for the question is a hint that two points are being sought in the response.

Results Plus: Examiner Comments

Use the number of marks as a guide.

(b)

There were 4 marks for this calculation of the speed of the car.

Mark 1 was for correctly reading the distance travelled from the diagrams.

Mark 2 was for correctly using v=s/t to calculate the speed.

Mark 3 was for a correct conversion between km/h and ms^{-1}, either for the actual speed or for the speed limit.

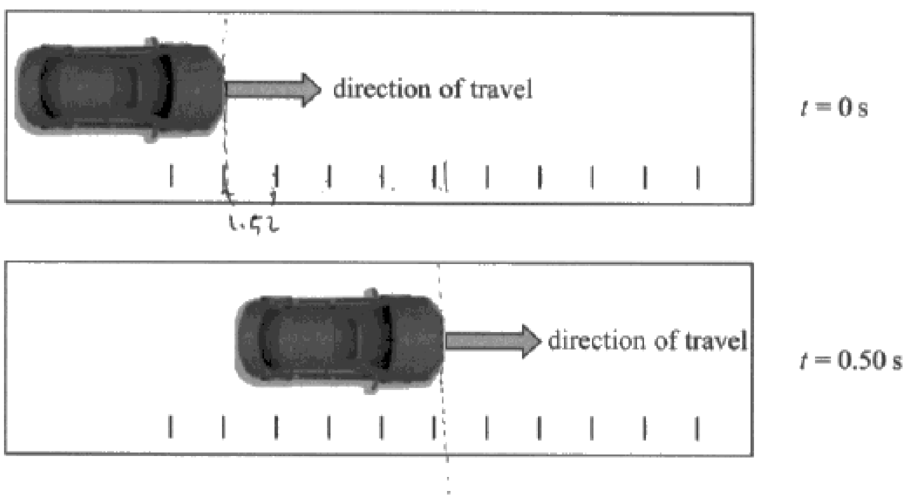
Mark 4 was for a correct final speed and a correct comparison with the speed limit showing that the speed was below the limit.

This question was generally answered well, and the greatest error the examiners found was the candidates' difficulty in correctly measuring and calculating the distance travelled. It was disappointing that most candidates took the distance moved along the road as exactly 4 divisions. We were hoping they would have been able to subdivide the divisions, giving the correct value of 4.2, but most just read the distance to the nearest whole division. This was allowed, but when the divisions are as large as the ones in this question, we had hoped that they would have subdivided them. Many candidates took the number of divisions as 5, or took measurements from the start of the diagram, in which case they would lose both the first and final marks. The units conversion was generally done correctly, but a number of candidates lost the final mark by omitting to compare their answer for the speed with the speed limit, which was the requirement given in the question.

These three examples of the responses seen are all good responses that gained the full 4 marks, but in different ways. They show how different approaches by the candidates are both acceptable and welcome when answering questions like this one, where the context is probably not one with which they have had any practise. The responses show the candidates' ability to apply the physics they have learnt to a new situation.

(b) The diagrams below show the positions of a car at a time interval of 0.50 s.

The markings are painted on the road at intervals of 1.52 m.



The speed limit is 50 km per hour.

Determine, using information from the diagrams, whether the car was exceeding the speed limit.

(4)

4.2 intervals for 0.5 seconds.

4.2 × 1.52 = 6.384 m

$\frac{6.384\text{m}}{0.5\text{ s}}$ = 12.76m/s

12.76m/s = 0.01276km/s

0.01276km/s = <u>45.9km/h</u>

∴ the car was not exceeding the speed limit.

Results Plus: Examiner Comments

This candidate has accurately measured the distance as 4.2 divisions and converted that to a distance. The speed has then been calculated, and converted to km/h, with a final statement that this puts the speed below the speed limit. We would have liked to see the statement that 45.9km/h<50km/h, but did not penalise that in the marking of this question.

Results Plus: Examiner Tip

Take readings accurately from a diagram, drawing lines on the diagram, if necessary, as this candidate has done.

∘ speed = $\frac{\text{distance}}{\text{time}} = \frac{4 \times 1.52\text{m}}{0.5\text{s}} = \underline{\underline{12.16\text{ms}^{-1}}}$

∘ 50km/h = $\frac{50 \times 1000\text{m}}{1 \times 3600\text{s}} = \underline{\underline{13.88\text{ms}^{-1}}}$

12.16 ms⁻¹ is speed of car, this is less than the speed limit of 13.88 ms⁻¹, hence car not exceeding speed limit.

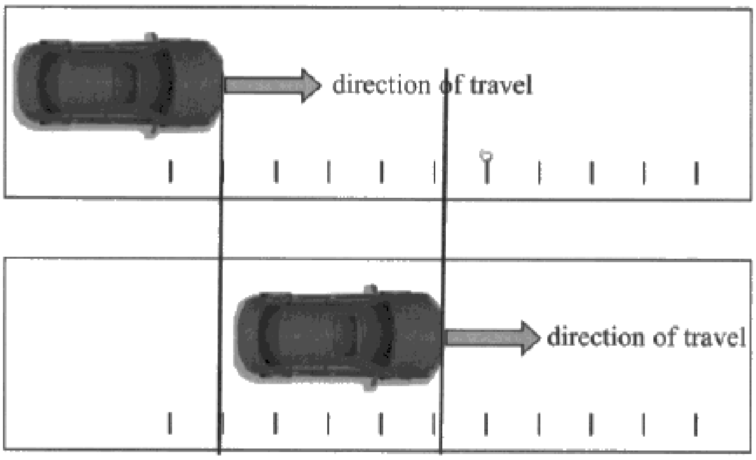
Results Plus: Examiner Comments

This candidate has converted the speed limit to 13.9km/h, which is perfectly acceptable. We allowed the use of just 4 divisions, and as the comparison of the correctly calculated speed in ms^{-1} with the speed limit in ms^{-1} is clear, all 4 marks are awarded.

(b) The diagrams below show the positions of a car at a time interval of 0.50 s.

The markings are painted on the road at intervals of 1.52 m.

0.8 cm = 1.52 m



$t = 0$ s

$t = 0.50$ s

The speed limit is 50 km per hour.

Determine, using information from the diagrams, whether the car was exceeding the speed limit.

(4)

$\frac{3.4}{0.8} \times 1.52 = 6.46$ m

$50\ \text{kmh}^{-1} = \frac{50 \times 10^3}{3600}$

$v = \frac{6.46}{0.5}$

$= 13.89\ \text{ms}^{-1}$

$= 12.92\ \text{ms}^{-1}$

• The speed of car is less than the speed limit. Hence, it was not exceeding.

Results Plus: Examiner Comments

This type of response was quite common, and is perfectly acceptable, although it might take a little longer to complete. The candidate has drawn onto the diagrams, measured the distance travelled with a ruler, and divided that by the actual length of each division to give the number of divisions and hence the true distance travelled.

Results Plus: Examiner Tip

Do not assume there is a single correct method. Go with the way you best understand.

(c)

This item was worth a single mark for stating that there could be a parallax error in measuring the distance the car travels in the 0.5s. We were just looking for the word parallax, and we were expecting that word as it is a clear technical term. Many who seemed to understand the principle involved lost the mark for failing to say parallax.

There were many incorrect responses given, such as a zero error, human error, difficulty in reading the distance accurately, and reaction time.

This was a good response that gained the mark.

(c) The position of the camera may result in an error in the calculated speed.
Suggest why.

(1)

This is because if the camera is not exactly perpendicular to readings, this will cause parallax error and distance calculated will be incorrect.

(Total for Question = 7 marks)

Results Plus: Examiner Comments

In this case we were just looking for "parallax", but the extra description is useful and another time might gain further credit.

The next two responses did not gain the mark.

This is because the car is not stopped exactly at the divisions, ~~so~~ the camera reading doesn't show the exact distance.

(Total for Question = 7 marks)

Results Plus: Examiner Comments

This was quite a common response, but there is no reason for not mentally subdividing the large divisions, and is something the candidates at this level should be able to do.

Results Plus: Examiner Tip

There is no reason not to read a scale to a fraction of a division.

Reaction time ~~when~~ when using the camera.

Results Plus: Examiner Comments

This was another common, incorrect response. The camera does not have a significant reaction time.

Q18.

(a)(i) The Physics examined in this question was straightforward, however, due to two fluids being involved, as well as a reference to density in the stem, this question did not score well overall. The most common misconception was that, due to the decrease in density, the drop became lighter. This negated any mark the student may have earned for a correct statement as to an increase in upthrust. The majority of students scored 1 mark for the upthrust increasing, or an upwards resultant force, with few considering the step between the increasing volume and the increasing upthrust i.e. a greater volume of fluid displaced.
(a)(ii) Most students could correctly identify the three forces involved with a few students assuming that the wax drop was falling and adding the drag to the upthrust. Full credit was not given for an equation using symbols unless the symbols were defined as the question had asked for a word equation.
(b) This part of the question was answered more successfully. Perhaps because the responses required were more straightforward. A good range of scores were seen but surprisingly not all students commented on the decrease in temperature at the top, even if they had discussed its consequences. The student had to be clear as to whether they were describing the effect of a decrease in temperature on the wax drop or on the surrounding fluid. Some students did not grasp the concept, failing to realise that this was due to a decrease in temperature, answering in terms of increasing terminal velocity and increased drag.

Q19.

(a)

The most frequently awarded mark for this item was 1 with only the best students picking up a second mark for the correct direction for the vertical acceleration.

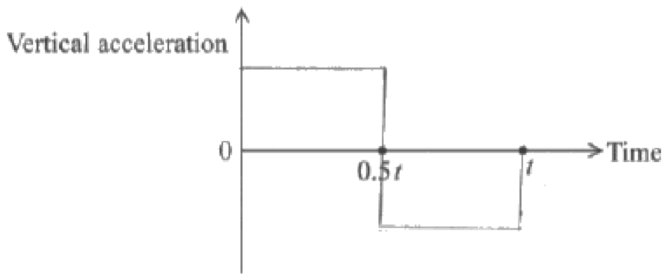
A wide variety of responses were seen for this question. Most common was a horizontal line changing direction at 0.5*t* suggesting that students thought that acceleration changed direction at the highest point. Even candidates that had a single horizontal line were evenly split between those who correctly drew a negative acceleration and those with an incorrect constant positive acceleration.

Diagonal lines were also fairly common suggesting that candidates thought they were drawing a velocity-time graph with curved lines suggesting a displacement-time graph.

This response scored 1 mark.

(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)



Results Plus: Examiner Comments

This was the most common response seen and scored 1 mark for the horizontal line i.e. a constant value of acceleration (ignoring the direction).

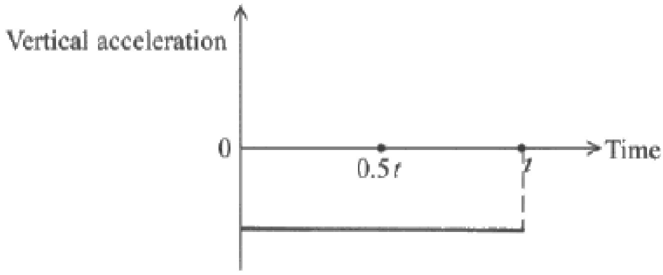
Results Plus: Examiner Tip

The downwards gravitational force causing the (negative) acceleration is constant and will be the same regardless of the direction of motion of the ball. Therefore the direction of the acceleration will be the same throughout the ball's motion, i.e. a constant negative value.

A good response scoring both the marks.

(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)



Results Plus: Examiner Comments

The graph shows a constant negative value for the acceleration ending at time *t*, when it is caught.

(b)

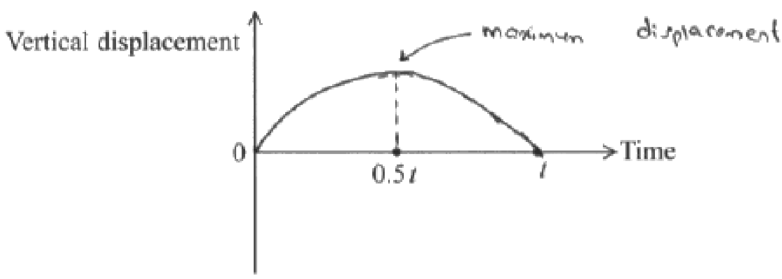
Across all abilities this question was not well answered. Candidates were expected to draw a parabolic curve ending at time *t* with a peak at 0.5*t*.

Candidates that drew the correct shape curve tended to score both marks placing the maximum and end points correctly. The most common response (awarded one mark) was a triangular shaped graph with a peak at 0.5*t*. A common incorrect response was one which included a horizonal line, symmetrical parabolas or upside down parabolas.

This response scored both marks.

(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)



(Total for Question 12 = 4 marks)

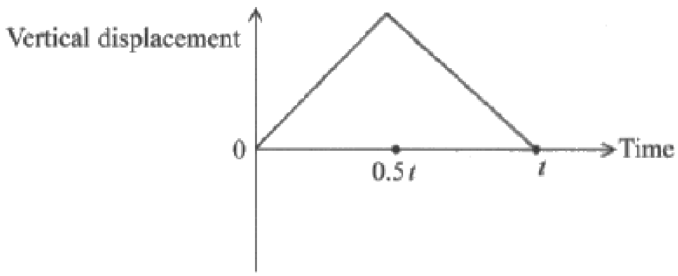
Results Plus: Examiner Comments

This was not the most precise curve but the shape was considered to be parabolic so this could get MP1. The maximum value was at 0.5*t* and it ended at time *t* when the ball was caught scoring MP2 as well.

1 mark scored.

(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)



(Total for Question 12 = 4 marks)

Results Plus: Examiner Comments

This graph was very common and only scored the second marking point for a maximum at 0.5*t* and for ending at *t*.

Results Plus: Examiner Tip

The displacement-time graph for an accelerating object is not a straight line, that would be for an object travelling at a constant velocity.

Q20.

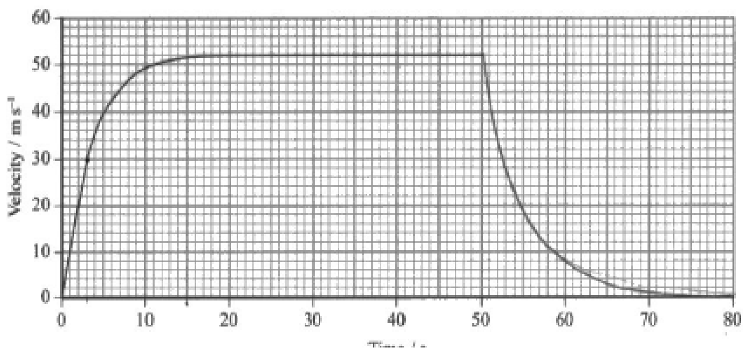
(a)

The command word for this question required an explanation of the shape of the graph rather than just a description of its shape in terms of the velocity or acceleration as time progresses. This question provided good discrimination between the candidates of different abilities, although the more able candidates did not always answer as well as expected.

Although many candidates knew that the weight was acting downwards, very few managed to explain that this was the only force acting initially. The mark scheme for MP1 demonstrates the many ways that this could have been expressed. A typical answer tended to state that initially the weight was greater than the drag and the upthrust, this would not score the first mark. Most candidates managed to link the increase in velocity to an increase in drag however fewer candidates managed to then describe the decreasing gradient in terms of the decreasing resultant force for MP3. To the credit of the teaching nearly all candidates identified that the final period of constant velocity was obtained when the forces were balanced, scoring the final marking point.
Free-fall and terminal velocity has appeared on quite a number of previous exam series. To explain the motion of the object falling many more points could be made. The most significant features of the graph i.e. initial maximum gradient, decreasing gradient and a gradient of zero were identified as the main features that candidates would be required to explain in terms of their knowledge of physics. Generally however, an answer in terms of the initial, decreasing and then zero resultant force with explanations as to why the resultant force is changing will cover any requirements of the question.

(b)

A small addition to a graph can demonstrate enormously a candidate's understanding of the context and the Physics involved. This should not be an unfamiliar context to many candidates however the graphs produced were of varying quality. A vertical line was not acceptable as it would assume that the skydiver decelerated instantaneously i.e. the parachute provided an infinite acceleration. Therefore a slight negative gradient was required.
Examiners expected to see a deceleration over a short period of time (no more than 10 s) to a lower value of terminal velocity. Although the example below has the correct shape graph for a deceleration they have drawn this over 20 s which was too long. They also have the skydiver decelerating to a rest rather than a lower value of the terminal velocity. Therefore, what looks, on first inspection like a good graph actually scored 0 as the Physics has not been applied sensibly to the context.



(c) (i)

While many candidates managed to identify that the terminal velocity would increase if the mass of the skydiver was greater, few managed an explanation in terms of the increased drag that would be required to equal the greater weight. Many candidates were thinking along the right lines in stating that the time taken to reach the terminal velocity would be greater, but often did not link this to a greater terminal velocity or give an explanation as to why it would take longer, i.e. to reach a greater terminal velocity.

(c) (ii)

There were some good answers seen to this question but powers of expression failed some candidates who suggested 'fall horizontally'. A few candidates did not realise the significance of the question numbering and the 'before he opened his parachute' in part (c)(i). Therefore responses that referred to the parachute a means of increasing the surface area were not awarded MP2.

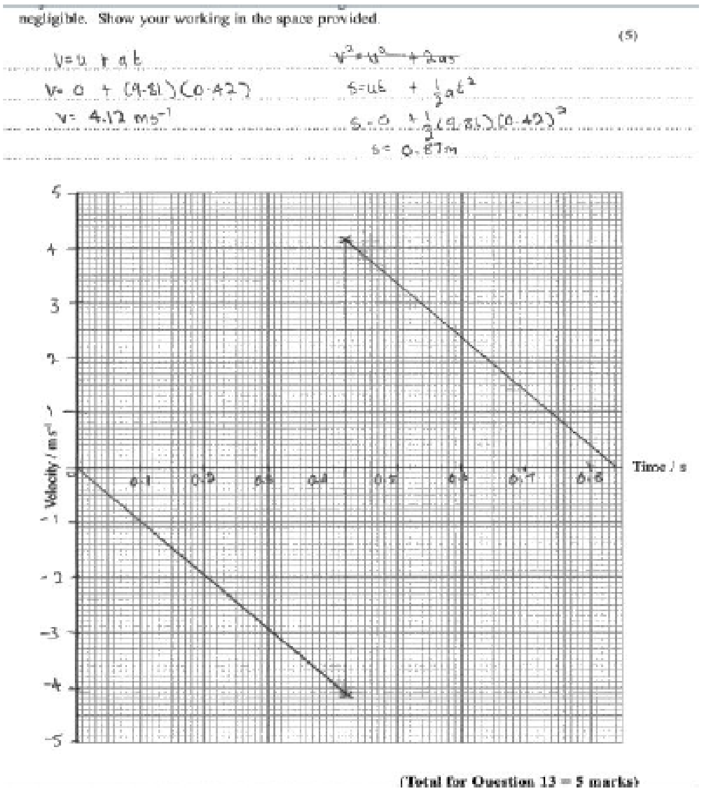
(d)

It can be seen from the given graph that terminal velocity is reached very shortly after leaving the plane therefore candidates had to appreciate that both skydivers were travelling at the same speed when the first parachute was opened. Less able candidates assumed that opening the parachute created an upwards acceleration, moving the skydiver upwards, rather than just a deceleration. However, many managed to score this first mark. An appreciation that the filming skydiver just continued as the same constant velocity was not realised by many, with many responses referring to this skydiver continuing to accelerate, thus MP2 was not awarded as frequently.

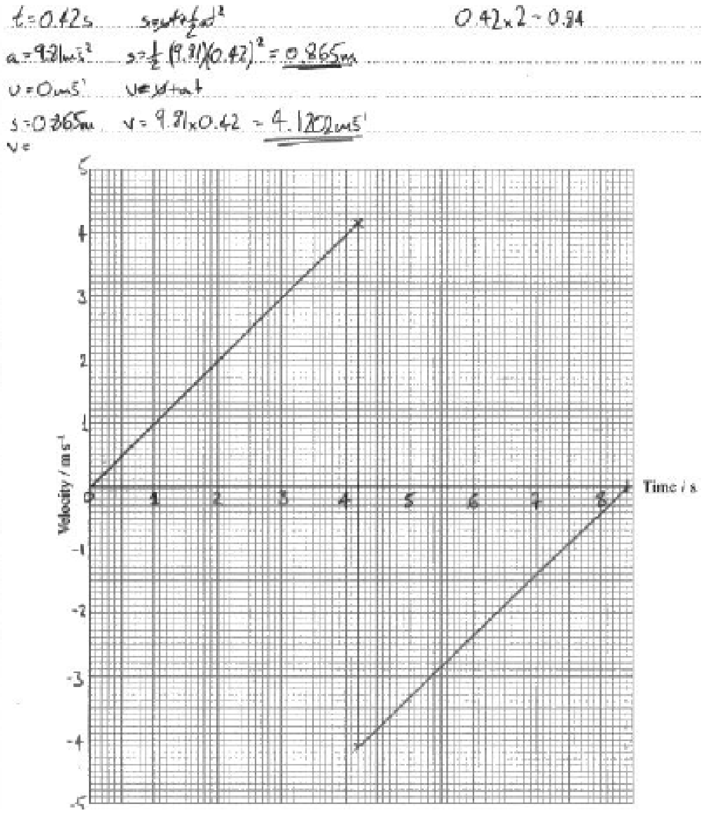
Q21.

Questions requiring candidates to plot a graph using only a few pieces of information demonstrates well the understanding of the subject as a whole. More thought and knowledge is required than just using an equation is required to score well. While the vast majority of candidates could correctly calculate the maximum velocity of the ball, the first skill that candidates were required to demonstrate was the scaling of the axes. This required then to appreciate that the total time involved was 0.84 s as the ball bounces and that the direction of the ball would change once the ball had bounced. The scaling mark cost many good candidates 3 of the 5 marks, as without it many could not pick up the two plotting marks (MP3 and 5).
Common errors included:
Assuming the given time of 0.42 s was for the entire motion of the ball and therefore using half the given time in the correct equation
Assuming that the impact time was not negligible and therefore drawing a line with a positive gradient linking the positive and negative velocities over the time of impact
Incorrect plotting, out of the 1 square (2mm) tolerance
No plotting at all, just sketching the graph for a bouncing ball. Thus missing the instruction to show any working and use the given information.
Although direction was not defined and candidates could choose this themselves, the vast majority of candidates took down to be positive.

The example below scored all 5 marks.



The example below scored just 2 marks. The time axis has been incorrectly scaled so therefore the scaling mark (MP2) and both plotting marks (MP3 and MP5) could not be awarded.



Mark Scheme

Q1.

Question Number	Answer	Mark
	B – −7.5 m s^{-2} as this is the gradient of the graph.	**1**
	Incorrect Answers: A – because this answer is positive and the gradient is negative. C – an incorrect calculation of gradient (= 15/4), and positive. D – an incorrect calculation of gradient (= 15/4).	

Q2.

Question Number	Answer	Mark
	C – as it shows a constant acceleration for the constant resultant force.	**1**
	Incorrect Answers: A – since this graph shows a constant velocity. B – since the graph is plotted against distance, not time. D – since this shows an increasing acceleration.	

Q3.

Question Number	Answer	Mark
	A	**1**

Q4.

Question Number	Answer	Mark
	D	**1**

Q5.

Question Number	Answer	Mark
	C – 30 m which is the magnitude of the area under each part of the graph added together.	1
	Incorrect Answers: A – This is the final displacement. B – This is the area under one part of the graph. D – This is a wrong calculation (15 × 4)	

Q6.

Question Number	Answer	Mark
	B	1

Q7.

Question Number	Answer	Mark
	D	1

Q8.

Question Number	Answer	Mark
	D	1

Q9.

Question Number	Answer	Mark
	D	1

Q10.

Question Number	Answer	Mark
	A	1

Q11.

Question Number	Answer	Mark
	C	1

Q12.

Question Number	Answer	Mark
	A	1

Q13.

Question Number	Answer		Mark
(a)	Reference to a tall container containing oil [for tall on diagram accept at least twice as high as wide] Markers away from top and the bottom (Measure) distance (between markers) using a metre rule (Measure) time to fall/travel using a stop watch Reference to repeating measurements (For MP3 & 4 the apparatus can be in a separate list or labelled on a diagram. MP1 & 2 normally from a diagram)	(1) (1) (1) (1) (1)	 **5**
* **(b)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** **In a vacuum** (the graph is a straight line as) the acceleration is constant/g/9.8 m s^{-2} (because) the only force is the weight/mg/gravitational (do not accept gravity) **In oil** (the graph curves then becomes horizontal) there is also upthrust **and** drag as speed increases, drag force increases Resultant force is/becomes zero **Or** U + D = W acceleration decreases until terminal velocity is reached **Or** velocity becomes constant when terminal velocity is reached **Or** acceleration becomes zero when terminal velocity is reached	 (1) (1) (1) (1) (1) (1)	 **6**
	Total for question		**11**

Q14.

Question Number	Answer	Mark
	C	1

Q15.

Question Number	Answer	Mark
	B	1

Q16.

Question Number	Answer	Mark
	C – velocity, since velocity has both magnitude and direction.	**1**
	Incorrect answers: A – distance has magnitude only. B – speed has magnitude only. D – work done has magnitude only.	

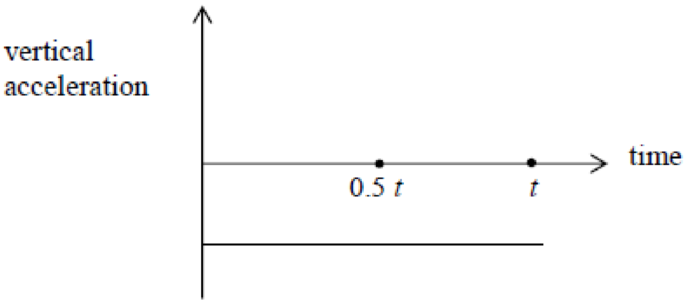
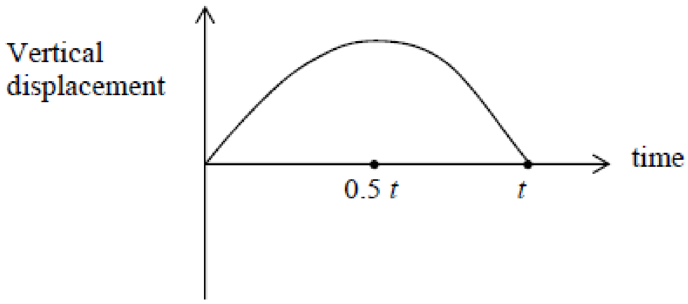
Q17.

Question Number	Answer		Mark
(a)	Total distance is used	(1)	
	(During the time interval) the speed could vary	(1)	**2**
(b)	Measurement from diagram leading to a distance travelled of 6.1 m to 6.5 m **Or** measurement from diagram of 4.0 to 4.3 divisions × 1.52	(1)	
	Use of $v = s/t$	(1)	
	Correct conversion between m s^{-1} and km per hour [either actual speed or speed limit]	(1)	
	v = 44 to 47 (km per hour) **and** car not speeding **Or** v = 12 to 13 (m s^{-1}) **and** limit is 14 (m s^{-1}) **and** car not speeding	(1)	**4**
	Example of calculation Number of markings crossed in 0.5 s = 4.2 4.2 × 1.52 m = 6.38 m $v = \frac{6.38\text{ m}}{0.5\text{ s}} = 12.77\text{ m s}^{-1}$ $v = \frac{12.77\text{ m s}^{-1} \times 3600\text{ s}}{1000\text{ m}} = 46.0$ km per hour		
(c)	Parallax error (in distance travelled by the car)	(1)	**1**
	Total for question		**7**

Q18.

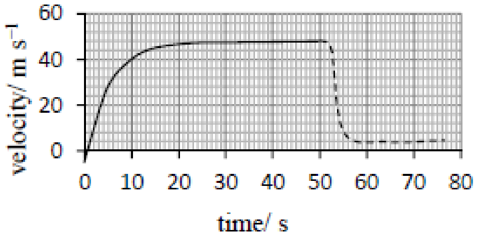
Question Number	Answer	Mark
(a)(i)	(For upward motion) the upthrust > weight (+drag) (1) **Or** there is a resultant upward force (This is because) greater volume/mass of liquid is displaced (1) (Accept more liquid displaced) Upthrust increases (and mass/weight of wax drop is constant) (1)	**3**
(a)(ii)	Upthrust, weight and (viscous) drag identified as the three forces (1) Correct equation e.g. upthrust = weight + drag **Or** upthrust − weight –drag = 0 (1) (Max 1 for undefined symbols used)	**2**
(b)	**Either** Temperature decreases (1) Density of drop increases (1) Upthrust reduces (1) **Or** Temperature decreases (1) Viscosity (of clear liquid) greater (1) Drag will be greater (at the top) (1)	**3**
	Total for question	**8**

Q19.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>(a)</td><td>Horizontal line(s) (1)
With a <u>constant</u> negative value ending at approximately time t (1)

</td><td>2</td></tr>
<tr><td>(b)</td><td>Parabolic curve by eye (1)
(height caught not specified so allow all possibilities, 0 displacement may be taken as ground or at height from which it was hit)
Maximum positive value at time $0.5t$ and ending at t (1)

</td><td>2</td></tr>
<tr><td></td><td>Total for Question</td><td>4</td></tr>
</table>

Q20.

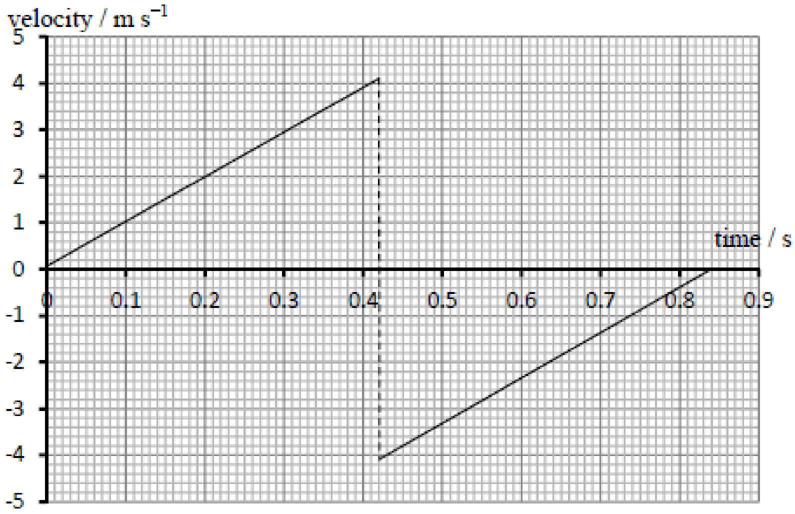
Question Number	Answer		Mark
*(a)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** Initially: drag = 0 **Or** $a = g$ **Or** maximum acceleration **Or** initially weight = resultant force **Or** weight is the only force acting	(1)	
	drag increases with velocity/speed **Or** drag is proportional to velocity/speed (squared)	(1)	
	resultant force decreases	(1)	
	Until drag (+ upthrust) = weight **and** acceleration is now zero (so gradient is zero) **Or** resultant force = 0 **and** acceleration is now zero (so gradient is zero)	(1)	**4**
	(MP4 allow velocity is constant or terminal velocity is reached for acceleration is zero)		

(b)	Sudden decrease in velocity (straight line but not vertical or a curve over maximum of 10 s)	(1)	
	To a new, lower (greater than 0) value of terminal velocity for at least 5 s	(1)	**2**
			

(c)(i)	Terminal velocity increases as weight/mass increases	(1)	
	A greater drag force is needed to equal the (increased) weight **Or** a greater drag force to make the resultant force zero	(1)	**2**
(c)(ii)	Increase drag force	(1)	
	The idea that he should make a less streamlined shape as he falls **Or** increase surface area (MP2 cannot be awarded if there is any reference to the parachute)	(1)	**2**
(d)	The skydiver with the open parachute slows down	(1)	
	The skydiver that is filming remains at constant/terminal velocity/speed **Or** the film shows relative velocity (between the two skydivers)	(1)	**2**
	(MP2 is not awarded if there is a description of the filming skydiver accelerating)		
	Total for question		**12**

Q21.

Question Number	Answer		Mark
	Use of $v = u + at$	(1)	
	Axes scaled correctly (+ and – velocity and time axes scaled appropriately)	(1)	
	Line from (0, 0) to (0.42, 4.1)	(1)	
	Vertical line linking positive and negative velocity (accept use of candidate's velocity, allow 1 square tolerance)	(1)	
	Line from (0.42, −4.1) to (0.84, 0) (accept candidate's velocity)	(1)	5

	(accept the negative version of this graph, taking positive as upwards) <u>Example of calculation</u> $v = 0 + (9.81\ \text{N kg}^{-1})(0.42\ \text{s}) = 4.12\ \text{m s}^{-1}$ 	
	Total for question	**5**