Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a	i	Curve starts at (0,0) with gradient decreasing to a maximum value 30 on vertical axis matching highest point of candidate's line	B1 B1	Accept horizontal asymptote NB ignore candidate's response after their line reaches 30 (m/s) **<u>Examiner's Comments</u>** Most candidates used the grid effectively to put a suitable scale on the speed axis. They also communicated that the maximum speed was 30 m s^{-1}. Many candidates also got the shape of the curve correct, which starts with maximum gradient and then flattens out.
		ii	Resistive force increases (with speed) Zero net or zero resultant force	B1 B1	Allow drag / (air) resistance / friction for 'resistive force' Allow resistive force = component of weight down the slope NOT simply idea of resistive force = weight **<u>Examiner's Comments</u>** While many candidates appreciated that the car reached a maximum speed because the resultant force was zero, some contradicted this by saying that the weight = drag (as it would be in vertical motion) or something else incorrect. Far fewer candidates stated that the drag increases with speed effectively. Quoting the given expression $F = kv^2$ was deemed insufficient. **Examination Tip** Repeating information given in the question is rarely creditworthy by itself.
		iii	Component of weight down slope = 9300 sin 5°	M1 M1 A1	Allow 810 or 811 seen Allow substitutions for variables

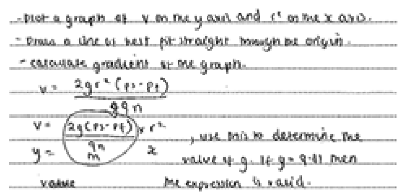
			Re-arrange to (k=)$F \div v^2$ (k=)810 ÷ 900 = 0.9…		Mark is for substitution <u>and</u> candidate's value seen **<u>Examiner's Comments</u>** As this question is a 'show that', all steps were required. Many candidates omitted the rearrangement stage, restricting their maximum score for this item to 1 mark. This approach was consistent throughout the paper for this type of question. **Examination Tip** Make sure that all steps of working are presented in 'show that' questions, especially the step that shows the relevant quantity as the subject of the equation. Always show your evaluation to at least 1 more significant figure than that shown in the question.
	b		evidence of substitution of $F=kv^2$ into $P = Fv$ $v = (P \div k)^{1/3}$ v = 44 (m s^{-1})	C1 C1 A1	e.g. $P = kv^3$, $P = (kv^2)\ v$, etc Allow use of k = 1 which gives 42 Allow answer within range 36 to 53 **<u>Examiner's Comments</u>** The key idea here is that the force from the engine (given by F = P / v) will equal the resistive forces (F = kv^2) when the car is at maximum speed. Candidates could choose which value of k they used here, either k = 1 from the question data or the value of k from the previous item. This gives an acceptable range of speeds as stated in the mark scheme.
	c		Power is proportional to the speed cubed / Max speed is proportional to the cube root of max power / power proportional to speed x kv^2 Valid reference to the cube root of 2 increase in velocity for double power /	B1 B1	NB cube root of 2 is 1.2599… e.g. 1.26 × 44 = 55 (m s^{-1}) **<u>Examiner's Comments</u>** Even if they couldn't complete the calculation in the previous item, candidates needed to be able to state the idea qualitatively for the first mark. No further calculations were required, except the correct answer that the

			Valid reference to factor of 8 increase in power for double the velocity		maximum speed would increase by a factor of cube root (2).
			Total	**12**	
2			Weight = air resistance (+ upthrust) Resultant force = 0 (N) acceleration = 0 (ms^{-2}) **Or** velocity/speed is constant	B1 B1 B1	**Allow** force due to gravity, *W*, *mg*, drag **Ignore** forces are balanced **Allow** net/total force **Ignore** velocity decreases **Allow** feather is not accelerating/no acceleration **<u>Examiner's Comments</u>** Candidates generally performed well on this question as many were given 1 or 2 marks for correctly explaining that the feather was falling at a constant speed because the weight acting on the feather was equal to the opposing force of air resistance. Some candidates explained this further by stating that the resultant force acting on the feather was 0.
			Total	**3**	
3	a		zero acceleration / constant velocity weight = drag (+ upthrust) zero <u>resultant</u> force (vertically)	B1 B1 B1	**Ignore** constant speed **Allow** W or mg or gravitational force for weight **Allow** air resistance for drag **Allow** resistive forces for drag (+ upthrust) **Allow** zero net / overall force (vertically) **Ignore** object is in equilibrium / forces are balanced **Not** there are no resultant <u>forces</u> (plural) **<u>Examiner's Comments</u>** It is important to read the question carefully here. Many candidates spent unnecessary time describing how an object which has been dropped from rest *reaches* terminal velocity, which was not required. There were several

					cases of careless terminology. For example, candidates often said that forces were balanced or matched (rather than equal and opposite), or that acceleration of gravity was the same as the drag force, or that acceleration was constant (rather than zero).
	b	i	Any two points from this list of three: • $v \propto r^2$ • (so) droplets with a small(er) <u>radius</u> have a small(er) *v* • (so) water droplets in mist must have a smaller <u>radius</u> (than water droplets of rain) Alternatively, **allow** any two points from the list below: • $v \propto (\rho_s - \rho_f)$ • $\rho_f \approx \rho_s$ for water droplets in <u>mist</u> giving $v \approx 0$ • $\rho_s > \rho_f$ (**or** $\rho_s \neq \rho_f$) for water droplets in <u>air</u> giving $v > 0$ (**or** $v \neq 0$) • ρ_f is greater in mist than air (with ρ_s constant) so *v* is smaller for water droplets in mist than for water droplets in air ORA	B1 x 2	**Allow** *v* increases with *r* (squared) OAW ORA ORA **Allow** density of water is similar to density of mist so $v \approx 0$ **Allow** water/rain is more dense than air so $v > 0$ **Allow** density of mist is greater than density of air so *v* is smaller for water droplets in mist than for water droplets in air ORA <u>**Examiner's Comments**</u> The density of water is the same in mist droplets and in rain droplets, and in both cases the droplets are falling through air. This means that the only variables in the formula are *v* and r^2, with *v* being proportional to r^2. Since mist droplets have a much lower terminal velocity *v*, this must be because they have a smaller radius than rain droplets. A reasonable suggestion using the formula, however, is that *v* is proportional to (ρ_s - ρ_f) and so this was given credit. Although the density of the water droplet, ρ_s, remains the same, some candidates argued that the air through which raindrops fall has a lower density to the water vapour through which mist droplets fall. This argument was much more popular than *v* proportional to r^2. Unfortunately, many candidates were too vague and struggled to distinguish

					between water, rain, mist and air. Some thought that density of air/mist > density of water giving a negative terminal velocity, which is impossible.
		ii	**Level 3 (5–6 marks)** Clear description (must check for *terminal* velocity) **<u>and</u>** Clear analysis (**either** correct answer for lowest *v* (allowing POT error) **or** method which at least partially verifies the expression) *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description (several points made, leading to a measurement of velocity) **<u>and</u>** limited analysis (as below) **<u>or</u>** Limited description **<u>and</u>** clear analysis (see above) *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description (eg at least one valid point made) **<u>or</u>** Limited analysis eg • incorrect expression used with correct values • incorrect values used in correct expression • 'plot a graph' but with incorrect axes / no mention of how to use the graph to verify the expression *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	B1 x 6	Use the annotations e.g. L2 for 4 marks, L2^ for 3 marks etc. Place the appropriate number of ticks below the annotation. **Indicative scientific points may include:** **Description of experiment to measure terminal velocity *v*** • Use a <u>long</u>, <u>clear</u> tube containing the liquid • Check the tube is vertical using a spirit level or plumb line • Measure a distance *d* using metre rule or tape measure • Measure a time *t* using a stopclock **or** light gates **or** give details of a video method • Describe a method to reduce parallax error • Describe a method to check that the spheres have reached *v* • Repeat using a different liquid and/or a different metal sphere • Possibly use several spheres with different values of *r*, measuring diameter *d* of spheres using callipers or micrometer **Analysis** • Calculate $v = d / t$ • Calculate $r = d / 2$ • Verify expression by plotting a suitable graph e.g. *v* against r^2 • and see if the results lie on a straight line through the origin • Verify expression by substituting into expression • e.g. calculating *g* from gradient and comparing result to 9.81 or comparing measured *v* to value of *v* predicted from expression

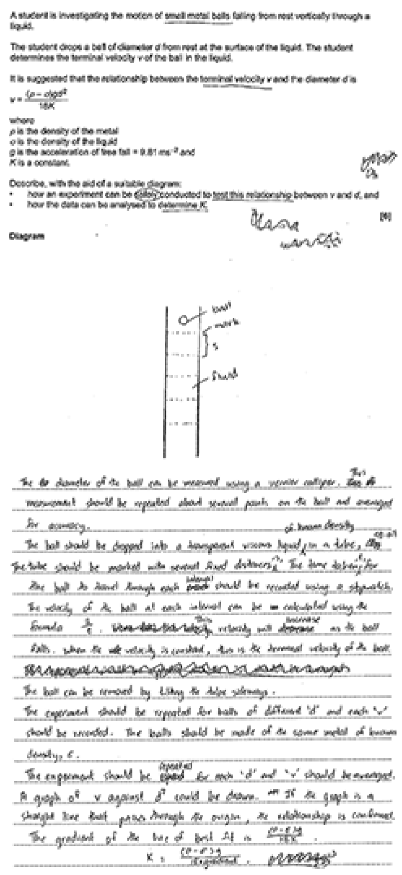
			0 mark *No response or no response worthy of credit*		• Steel spheres – lower ρ_s than lead so lower *v* • Sunflower oil – much higher *η* than water so lower *v* • Estimate lowest *v* = 0.075 m s^{-1} using steel and sunflower oil **Examiner's Comments** This experiment is one of the PAGs and it is essential that candidates explain how to verify that the sphere is falling *at a constant velocity* before *v* is measured. It is not enough to state that a long cylinder must be used or that *v* is measured near the bottom. It is important to describe which measuring instruments would be used and how the measurements taken would be combined to calculate *v*, rather than simply stating '*v* is measured using a light gate'. Some candidates did not read the question carefully and spent precious time explaining how to measure the density of the liquids and the spheres, which had been given in the table. They described carefully how to drop the sphere from exactly the same height each time using exactly the same amount of fluid, not realising that this would have no bearing on the terminal velocity. Candidates were asked to calculate the lowest terminal velocity possible using a sphere of diameter = 1 mm. Most candidates remembered to attempt this and correctly chose a steel sphere in sunflower oil. However, many used *η* = 50 rather than 50 × 10^{-3} and the majority used *r* = 1 mm rather than 0.5 mm. The purpose of the experiment was to verify the expression given in 4b(i) as accurately as possible. The best way to do this was to use a steel sphere in sunflower oil because then the sphere would be travelling more slowly, making it possible to measure *v* more accurately. The radius of the sphere

					could be varied and a graph of *v* against r^2 plotted. If the expression given is correct, then the graph would be a straight line *through the origin*. The gradient should be equal to $2g(\rho_s - \rho_f)/9\eta$ and, by using the values given in the table, $g \approx 9.81$ m s^{-2} could be verified. It is also possible to use the 4 different combinations of liquid and solid sphere of constant radius and plot a graph of *v* against $(\rho_s - \rho_f)/\eta$. Candidates should make sure that they state very clearly how their experiment can be used to verify the expression. A typical response was along the lines of 'I would measure *v* several times and take an average, then plot the results on a graph'. How are you going to get more than one result (you need at least four for a reasonable graph)? What are you going to plot and on which axis? Have you taken all the variables into account? How will you use your graph to show that the expression is correct? Exemplar 2  This response demonstrates good practice.
			Total	**11**	
4			**Level 3 (5–6 marks)** Clear description of method including a diagram **and** clear explanation as to how the data can be analysed to determine *K* *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	B1 × 6	Use level of response annotations in RM Assessor **Indicative scientific points may include:** **Description of method** • Diagram showing liquid in a container

			Level 2 (3–4 marks) Some description of method **and** some analysis of data **or** Clear description of method including a diagram but limited analysis **or** Limited description but explanation as to how the data can be analysed to determine K *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description **or** Limited analysis *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 mark** *No response or no response worthy of credit.*		• Marks added to side of container • Use of stopwatch to measure time t for fall • Repeat measurements of t and average t • Repeat for different d • Measure d with a micrometer / calipers • Repeat measurements of d in different directions • Method to determine density of balls • Method to determine density of liquid • Method of ensuring v is terminal velocity • Method to remove balls from cylinder • Container in a tray / supported • Use of a tall container **Analysis of data** • v = distance / time • density = mass / volume • volume of ball $= \frac{4\pi r^3}{3}$ • 3 Plot graph of v against d^2 • If relationship is correct, graph should be a straight line passing through the origin • $K = \frac{(\rho - \sigma)g}{18 \times \text{gradient}}$ **<u>Examiner's Comments</u>** This question enabled candidates to plan an experiment. In candidates' descriptions it was important to include how the independent and dependent variables were measured. Candidates could also explain how the density of the ball and liquid could be determined. Many candidates did not explain how the terminal velocity could be determined. Often descriptions was just timing the ball leaving the surface to the bottom. Some high scoring candidates discussed the need to check between successive distances that the velocity was constant.

To determine the value of constant *K* it was expected that the axes of an appropriate graph would be suggested with an equation with *K* as the subject to indicate how the gradient could be used.

Exemplar 1



A student is investigating the motion of small metal balls falling from rest vertically through a liquid.

The student drops a ball of diameter *d* from rest at the surface of the liquid. The student determines the terminal velocity *v* of the ball in the liquid.

It is suggested that the relationship between the terminal velocity *v* and the diameter *d* is

$$v = \frac{(\rho - \sigma)gd^2}{18K}$$

where
ρ is the density of the metal
σ is the density of the liquid
g is the acceleration of free fall = 9.81 m s^{-2} and
K is a constant.

Describe, with the aid of a suitable diagram:
- how an experiment can be safely conducted to test this relationship between *v* and *d*, and
- how the data can be analysed to determine *K*.

[6]

Diagram

This candidate starts their response by drawing a sketch diagram with markings on the side of the tube experiment. This diagram could be improved – it would have been helpful to have seen the bench for example. However, it does indicate that the candidate is thinking about terminal velocity.

The description of the experiment is logically structured and contains appropriate detail, for example a viscous liquid oil. This candidate has included a method to measure the diameter of the balls.

Importantly the candidate explains

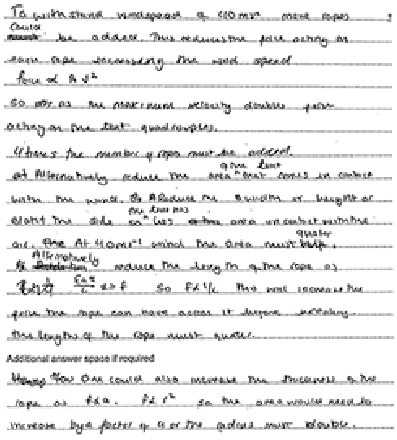
					how terminal velocity is determined using the marks on the side of the tube. There is then a clear section of how the results could be analysed including an appropriate graph and then how *K* could be determined from the gradient. Overall, this candidate has provided a good description of the method including how terminal velocity is determined and how the data can be analysed. The information is clearly and logically structured and is relevant. **Assessment for learning** Practical techniques Candidates should have experience of describing methods as well as analysing data.
			Total	**6**	
5	a		time measured is small **/** velocity of soil is high video camera measurements can have a smaller resolution (time or distance) / measurement with a stopwatch would have a large uncertainty (due to reaction time)	B1 B1	**ALLOW** observation can be replayed/slowed down so removes effect of human reaction time **ALLOW** human reaction time is large/~0.2s (compared to time interval) **IGNORE** human error **<u>Examiner's Comments</u>** Just under half of candidates scored 1 mark for giving a reasonable explanation for the more appropriate use of a video camera to measure the time by reasoning that timing with the stopwatch was affected by human reaction time or that the uncertainty in the measurement was greater when using the stopwatch. Many responses from candidates lacked detail and did not use scientific language including random error (due to the reaction time), resolution and uncertainty as a reason to explain why the video

					camera was more appropriate. Some responses were often simplistic as candidates gave responses discussing accuracy and human error which was not given.
	b		method to avoid parallax errors	B1	**Examiner's Comments** Candidates did not perform well on this question.The most common response was to suggest that repeat readings of the distance were taken to then calculate a mean value. While this was a reasonable and sensible suggestion it is not considered as a precaution as the correct response was to describe a method to avoid parallax error when measuring the distance the soil sample had fallen in the measuring cylinder. **Assessment for learning** Please refer to the Practical Skills Handbook for information on practical techniques including definitions of key scientific terminology and methodology.
	c		Uses $v = \frac{s}{t}$ using any two data points from 0.2s onwards to get 0.27 (m s^{-1}) Second calculation to show that the soil has reached terminal velocity	M1 A1	**ALLOW** some justification that the soil particle has reached terminal velocity e.g. the distance remains similar between intervals 0.2s, 0.3s, 0.4s and 0.5s **Examiner's Comments** A quarter of candidates correctly gave two calculations above a time of 0.3s to show that the soil sample had reached terminal velocity of 2.7 m s^{-1}. Many candidates calculated the distance that the soil sample had travelled for each 0.1 s interval which showed that the distance that the soil sample had travelled was 2.7 m but did not fully justify these values in relation to the soil sample reaching terminal velocity to secure 2 marks. Some candidates calculated the average velocity over the 0.5 s interval

					and then rounded it to show that it was about 0.3 m s^{-1} which did not receive credit.
	d		$\sqrt{\frac{9 \times 1.0 \times 10^{-3} \times 0.27}{2 \times 9.81 \times (1500 - 1000)}}$ / 5.0×10^{-4} (m) diameter = $5.0 \times 10^{-4} \times 2 / 1.0 \times 10^{-3}$ (m) diameter = 1.0 mm so sand	C1 M1 A1	**ALLOW** use of v = *0.3* m s^{-1} giving r = 0.52mm, d = 1.0mm so sand **ALLOW** alternative correct calculation of v for range of r for each soil sample to give sand e.g., r=0.001x10^{-3}m gives v=1.09x10^{-6}ms^{-1}, r=0.025x10^{-3}m gives v=6.8x10^{-4}ms^{-1} and r=1x10^{-3}m gives v=1.09ms^{-1} so 0.3ms^{-1} (0.27ms^{-1}) is within the v range of sand **<u>Examiner's Comments</u>** The performance on this question was variable as only just over half of candidates scored marks with only a quarter scoring full marks for determining the soil sample used by the scientist. Many candidates made errors when rearranging the equation of terminal velocity to give the radius, often by not taking the square root to give a value of the radius. In the subsequent step candidates were required to multiply the calculated value of radius by 2 to give the diameter and to convert from mm to m. These steps were often omitted and hence they used the radius value to determine the soil sample with most stating it was clay and as a result their answer was incorrect. Some candidates attempted to calculate the range of terminal velocities for each soil sample to then compare with the value 0.3 m s^{-1}. While this method was valid and given according to the mark scheme candidates did not always calculate the terminal velocity for each sample to then make a correct comparison and hence conclusion that the soil sample used was sand.
			Total	**8**	
6	a	i	(area of shaded region =) 1.9 × 6.0 or 11.4 (m^2) (volume of air in 3.0 s =) 11.4 × 3.0 ×	C1 C1	**Allow** volume found in one second leading to mass per second multiplied by 3 for 2^{nd} and 3^{rd} mark

			12 (mass of air = 11.4 × 3.0 × 12 × 1.2) mass of air = 492(.48) (kg)	A1	**Note**: volume of air is 410 (m^3)
		ii	Δp = 12 × 490 or 5900 (kg ms^{-1}) (force = Δp / Δt = 5900/3.0) F = 2000 (N)	C1 A1	Expect to see mass of 490, 492, 492.5, 492.48 **Note** answer is 1970 to 3 SF using 492.48 **Note** answer is 1960 to 3 SF using 490 **<u>Examiner's Comments</u>** Candidate's answers to this part were either jumbled or grounded in incorrect physics. This question is correctly answered by thinking about a cuboid of air that is 36 m long and has a cross-sectional area equal to that of the shaded side of the tent. That cuboid corresponds to the air that hits the tent in the three second period. The force applied will be equal to the rate of momentum change. This means multiplying the mass of air that hits the tent by the velocity change (i.e. 12 m/s) and then dividing by the time taken for that momentum change.
	b		***Level 3 (5–6 marks)** Clear descriptions **and** explanations, supported by quantitative analysis *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description and some explanation or quantitative analysis **or** Clear explanation	B1×6	**Indicative scientific points may include**: **Description** • Increasing the area/diameter of the guy ropes • A different material with a larger breaking or yield stress • A more streamlined shape that allows the wind to pass over or around the tent **Explanation**

			or Clear description **or** Clear quantitative analysis *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description **or** Limited explanation *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.*		• Correct reference/use of F = Δp / Δt • Greater cross-sectional area of rope would reduce the stress • The rope would not exceed a higher breaking/yield stress • Changing shape produces a smaller momentum change and a smaller force • If the air passes over/around the tent, it still has some forward momentum and hence the change and force is less • Reduction of angle of ropes from ground reduces component of tension perpendicular to ground so tension decreases. **Quantitative analysis** • Mass (per unit time) and velocity **both** double (at 40 m/s) • Momentum change is ×4 • Force would increase by a factor of 4 • Rope cross section must be × 4 (or diameter × 2) • Breaking or yield stress of material would need to be × 4 • Use of trigonometry to determine the angle of deflection that would reduce the momentum change by a factor of 4 (about 15° compared to the original 90°) **<u>Examiner's Comments</u>** This question tested ideas about forces, resolution of forces, behaviour of materials under stress and rate of change of momentum transfer. Level 1 answers were restricted to merely suggestions of what could be done to make the support of the tent stronger. Level 2 answers developed at least one of those suggestions by referring, qualitatively, to the underlying physics. Level 3 answers were rare, as the

					requirement was for some quantitative physics. Candidates that attempted a quantitative answer often believed that the force would be doubled, when in fact it is quadrupled. This is because both the mass of the air depends on the velocity of air, so doubling the speed will also double the mass, thus quadrupling the momentum transfer.  This candidate clearly states, on lines 3–5, that the force is directly proportional to the square of the speed by thinking about their answers to previous parts of the question. The statements following this, after the page break, are sensible and grounded in physics in topics typically covered in the first year of study. The candidate mentions about quadrupling the number of ropes and reducing the area presented to the wind by a factor of four. The candidate goes on, in the additional answer space, to refer to the thickness of the ropes and how the radius would need to double. Level 3 response.
			Total	**11**	
7	a		$\rho = \frac{169-96}{87}$ or $\frac{73}{87}$ $\rho = \frac{0.169-0.096}{87\times10^{-6}}$ or $\frac{0.073}{87\times10^{-6}}$ ρ (= 839) = 840 (kg m^{-3})	C1 M1 A0	**Ignore** power of tens **Note** power of tens must be seen for both mass and volume **<u>Examiner's Comments</u>** Most candidates were able to

					determine the mass of the oil correctly and divide the mass by the volume. A significant number of candidates did not demonstrate that 73 g was 0.073 kg and that 87 cm3 was 87 × 10^{-6} m^3. More able candidates clearly showed how the cm3 was converted to m^3.
	b		volume = $\frac{4\pi(8.1\times10^{-3})^3}{3}$ or 2.226 × 10^{-6} (m^3) OR 840 × 9.81 × candidate's volume 840 × 9.81 × 2.226 × 10^{-6} or 0.0183 0.018 (N)	C1 M1 A0	**Ignore** power of tens **Examiner's Comments** Candidates who understood that the upthrust was equal to the weight of the oil displaced scored well on this question. To score the marks it was necessary to show how the volume of the ball was calculated. Some candidates had difficulties with the powers of ten. Some candidates then went on to use one equation of density × volume × *g* while other candidates calculated the volume, then the density and then the weight. Both these methods were acceptable.
	c	i	Terminal velocity is when the velocity is constant (Terminal) velocity is determined from the gradient when graph is a straight line / constant gradient OR evidence of calculation of gradient of straight section	B1 B1 B1	**Allow** acceleration is zero for velocity is constant Check read-offs are appropriate. **Examiner's Comments** Candidates needed to describe and explain how the terminal velocity was determined from the graph. A good way of answering the question was to state what was meant by terminal velocity, explain how velocity could be determined from the displacement time graph and then state where the velocity was constant. Candidates who were successful demonstrated the gradient calculation of the straight section by substituting numbers into the gradient formula and calculating 1.8 m s^{-1}.
		ii	Tangent drawn at t = 0.2 s extends at least two large squares (0.2 s) in the *x*-direction	M1 A1	**Allow** 1.10 (ms^{-1}) to 1.30 (ms^{-1}) **Examiner's Comments**

			1.2 (ms^{-1})		High scoring candidates drew a tangent to the line at 0.2 s. **Misconception** The instantaneous velocity from a displacement time graph is equal to the displacement divided by time. **Assessment for learning** Candidates should practice drawing tangents to curves. The tangent should cover as much of the graph paper as possible. **Assessment for learning** Candidates should practice determining the gradient from a graph. Two data points should be selected from the line (not from a data table). The two data points should be easy to read from the graph and as far apart as possible (at least half the length of the straight line). The data points should clearly be substituted in the equation to determine the gradient *m*. $m = \frac{y_2 - y_1}{x_2 - x_1}$ The advantage of this method is that it also allows correctly for both positive and negative gradient graphs. Although the *y*-intercept did not have to be determined in this question, this method also help candidates to easily determine the *y*-intercept by substituting a data point from the graph used in the determination of the

					gradient, i.e. *y-intercept* = $y_2 - mx_2$ or $y_1 - mx_1$
	d		$\eta = \frac{0.017 \times 9.81 - 0.018}{6\pi \times 8.1 \times 10^{-3} \times 1.8}\left(= \frac{0.14877}{6\pi \times 8.1 \times 10^{-3} \times 1.8}\right)$ 0.54 kg m^{-1} s^{-1} OR N s m^{-2} OR Pa s	C1 A1 B1	**Allow** 0.55 **Note** for power of ten errors 607 or 0.607 or 5.4×10^{-4} scores one mark **<u>Examiner's Comments</u>** This was a challenging question and as a consequence some candidates only attempted to determine the unit. Common errors included either not allowing for the powers of ten correctly or not determining *F* as detailed in the question. Candidates also needed to determine the unit of η. A common incorrect unit seen was N s^{-1} m^{-2}. **Assessment for learning** Candidates should practice determining units in base units and checking the homogeneity of equations.
			Total	**12**	