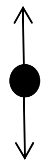
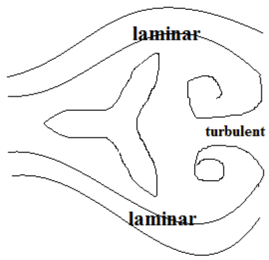
Question Number	Answer		Mark
1(a)	Reaction/ *R*/ (normal) contact force/ force of floor/force of lift (on passenger) etc. (not normal/*N*)  Weight/*W*/*mg* (Subtract 1 mark for each additional force/arrow if more than 2 forces on diagram. Arrows must begin on the dot)	**(1)** **(1)**	**2**
1(b)(i)	Calculates the difference between scale readings e.g (73g – 60g) or (73 – 60) or 128 (N) or 13 (kg) seen Use of $F = ma$ to find a Acceleration = 2.1 (m s^{-2}) <u>Example of calculation</u> Resultant force =(73 kg × 9.81 N kg^{-1})–(60 kg × 9.81 N kg^{-1}) = 127.5 N 127.5 N = 60 kg × a a = 2.13 (m s^{-2})	**(1)** **(1)** **(1)**	**3**
1(b)(ii)	Use of $a = \frac{v-u}{t}$ a = (−) 1.9 m s^{-2} <u>Example of calculation</u> a = [illegible] = −1.89 m s^{-2}	**(1)** **(1)**	**2**
1(c)	Arrows not required  Labelled region of laminar flow showing parallel streamlines. Labelled region of turbulent flowing showing adjacent streamlines crossing and/or eddies.	**(1)** **(1)**	**2**
	Total for Question		**9**

Question Number	Answer		Mark
***2**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 4** • (B and) C will stay in their seats • Resultant force acts/chair exerts force on (B and) C **Or** (B and) C will decelerate • Passenger A continues to move(at the same speed) [If the candidate implies that the passenger is being thrown/thrust/pushed forward do not award this mark] • Identifies movement of passenger A as Newton's first law [Not awarded for just quoting N1, it has to be in the context of the question] • A will collide with B	**(1)** **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question		**4**

Question Number	Answer	Mark
3*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (N1:) No acceleration / constant velocity ('constant speed' not sufficient)/ (at rest or) uniform motion in straight line (1) unless unbalanced/net/resultant force (1) [Converse: If $\Sigma F = 0$ / forces in equilibrium ('body in equilibrium', 'equal forces' not sufficient) 1 mark, there is no acceleration ('remains at rest' not sufficient)1 mark] (N2:) acceleration proportional to force / F = ma (1) Qualify by stating resultant/net force / $\Sigma F = ma$ (1) (Reference to 'resultant' for N2 may be credited elsewhere in the answer as they don't always put it with F = ma, but it must be clearly linked to N2.) ('External force' not sufficient) (For answers based on momentum, 'rate of change of momentum' proportional to force / $F = \Delta(mv)/\Delta t$) If (resultant) force zero, N2 → acceleration = 0 **OR** acceleration only non-zero if (resultant) force non-zero. (1) Names reversed, max 1 per each correctly, fully defined law (i.e. max 3) Last mark not awarded if laws not explicitly identified within question	
	Total for question	**5**

Question Number	Answer	Mark
4(a)	Free body force diagram, arrows must begin at the point shown – including: weight vertical, (W, mg, gravitational force – not 'gravity') friction and/or air resistance parallel to slope upwards, (D, V, F) normal contact force perpendicular to slope upwards. (ncf, N, R) 3 correct forces = 2 marks, 1 or 2 correct forces = 1 mark, Ignore arrows not coming from point Each incorrect force (e.g. pull down slope) decreases the maximum possible number of creditable forces by one Ignore upthrust.	**2**
4(b)(i)	Use of equations of motion sufficient to lead to answer (1) a = 0.9 (m s^{-2}) (1) <u>Example of calculation</u> $s = ut + ½ at^2$ 11 m = ½ a x (4.9s)^2 a = 0.92 m s^{-2}	**2**
4(b) ii)	Use of $F = ma$ (1) F = 36 to 40 N (1) <u>Example of calculation</u> $F = ma$ F = 40 kg x 0.92 m s^{-2} F = 37 N	**2**
4(c)(i)	Use of trigonometrical relationship (200 cos 20º) to resolve force (1) F = 152 N (1) <u>Example of calculation</u> Horizontal component of force = 200 N x cos 20º = 188 N 37 N = 188 N – resistive force resistive force = 151 N	**2**
4(c)(ii)	Use of work = force x distance (1) Use of work / time (1) Power = 420 W (1) For $P = Fv$, Find (or use) ave velocity (1), use of $P = Fv$ (1), correct answer (1) <u>Example of calculation</u> Work = force x distance = 188 N x 11 m = 2070 J Power = work / time = 2070 J / 4.9 s = 422 W	**3**
	Total for question	**11**

Question Number	Answer	Mark
5(a)	Show that the resultant force on the rocket is about 4×10^6 N Use of $W = mg$ (1) State or use resultant force = upward force – weight (1) Correct answer to at least 2 s.f. [4.2×10^6 N] (1) [no ue] **Example of calculation** W = mg $W = 3.04 \times 10^6$ kg x 9.81 kg m s^{-2} = 2.98×10^7 N Resultant force = 3.4×10^7 N – 2.98×10^7 N = 4.2×10^6 N	**3**
5(b)	Calculate the initial acceleration. Use of $F = ma$ (1) Correct answer [1.38 m s^{-2}] (1) [ecf] **Example of calculation** $a = F/m$ = 4.2×10^6 N / 3.04×10^6 kg = 1.38 m s^{-2}	**2**
5(c)	Calculate the average acceleration. Use of $v = u + at$ (1) Correct answer [15.9 m s^{-2}] (1) [beware same unit error as part b not penalised] **Example of calculation** $a = (v – u) / t$ = (2390 m s^{-1} – 0) / 150 s = 15.9 m s^{-2}	**2**
5(d)	Suggest a reason for the difference in the values of acceleration calculated. e.g. Mass decreasing / weight decreasing / net upward force increasing / fuel used up / gets lighter / *g* decreasing /air resistance decreasing with altitude (1)	**1**
	Total for question	**8**

Question Number	Answer	Mark
6(a)	What is meant by Newton's first law. reference to constant velocity OR rest and uniform motion in a straight line (1) reference to zero resultant force / unbalanced force (1) (examples: $\Delta v = 0$ if $\Sigma F = 0$; $\Delta v = 0$ unless $\Sigma F \neq 0$)	**2**
6(b) (i)	State 2 ways in which the forces in the pair are identical. 2 of magnitude, type of force, line of action, time of action (1) (1)	**2**
6(b) (ii)	State 2 ways in which the forces in the pair differ. <u>Opposite</u> direction, act on different bodies (1) (1)	**2**
6(b) (iii)	Describe the force that Newton's third law identifies as the pair of this force. <u>car</u> exerts <u>upward/opposite</u> force on <u>Earth</u> (the different points) (1) <u>gravitational</u> and <u>12 000 N/equal</u> (the identical points) (1) [no ue]	**2**
	Total for question	**8**

Question Number	Answer	Mark
7a **7b**	Describe how you could measure *g* **QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Max 6 marks state sufficient quantities to be measured (e.g. *s* and *t* OR *v*, *u* and t OR *u, v* and *s*)) (1) relevant apparatus (includes ruler and timer/data logger/ light gates) (1) describe how a distance is measured (1) describe how a speed or time is measured (1) further detail of measurement of speed or time (1) vary for described quantities and plot appropriate graph (1) state how result calculated (1) repeat and mean (one mark max for any relevant quantity/result) (1) Precaution – a precaution relating to experimental procedure (1)	**Max 6** **1**
	Total for question	**7**

Question Number		Mark
8(a)	Graph does not have a zero gradient **Or** Graph does not shows constant velocity **Or** the velocity is constantly changing **Or** Graph always shows an acceleration (or deceleration) **Or** Graph not horizontal/ flat **Or** Graph not parallel to the time/x-axis **(1)** (Accept 'line/gradient/tangent' in place of 'graph')	**1**
8(b) (i)	Use of gradient of tangent **(1)** a = 6.5 to 7.4 (m s^{-2}) (conditional mark) **(1)** (Check graph to make sure that the values have been read accurately from the graph, misreading from the graph will only score 1 mark even if the answer falls in the above range) <u>Example of calculation</u> Acceleration = $\frac{8.0\text{ m} - 1.2\text{ m}}{1.0\text{ s}}$ Acceleration = 6.8 m s^{-2}	**2**
8(b)(ii)	Use of $F = ma$ **(1)** F = 0.016 to 0.018(N) (ecf acceleration from (b)(i)) **(1)** <u>Example of calculation</u> F = 6.9 m s^{-2} × 0.0024 kg = 0.017 N	**2**
8 (b) (iii)	Use of W = mg **(1)** Drag = 0.006 to 0.008(N) (ecf) **(1)** <u>Example of calculation</u> W = 0.0024 kg ×9.81 N kg^{-1} = 0.0235 N 0.017 = 0.0235 – drag Drag = 0.0065 N	**2**
8 (b) (iv)	Use of Stokes' law equation with velocity either 5.2 m s^{-1} or 6.6 m s^{-1} **(1)** F = 3.5 × 10^{-5} (N) or 4.5 × 10^{-5} (N) (no unit error) **(1)** <u>Example of calculation</u> $F = 6\pi\eta rv$ = 6π × 1.8 × 10^{-5} × 2 × 10^{-2} × 5.2 m s^{-1} = 3.5 × 10^{-5} N	**2**

8 (c)(i)	Correctly identifies a region of laminar flow and region of turbulent flow **(1)**	
8 (c)(ii)	the idea that there is turbulent flow **Or** ball is moving fast **Or** this is a large sphere **Or** Statement about Stokes law force for laminar flow only **Or** Stoke's law assumes that the ball is moving slowly (which this is not) **Or** Stoke's law is for a small sphere (and the hollow ball is large) **(1)** **Or** A large amount of eddies increases the drag	1
8 (d)	**Max 3** Falls with constant acceleration **(1)** At about 0.8 s: the ball bounces **Or** the ball changes direction **(1)** Speed of ball after the bounce is less than the speed before the bounce **(1)** Max height reached at about 1.3 s. **(1)** Accelerations are the same before and after the bounce **(1)**	**3**
	Total for question	**14**