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> $a = \frac{0-10\ m\ s^{-1}}{8.9\ s} = -1.89$ m s^{-2}	**(1)** **(1)**	**2**

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)**	**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 / $\boldsymbol{F} = \Delta(mv)/\Delta t)$ 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) Example of calculation $s = ut + ½\ at^2$ 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) Example of calculation ***F = ma*** ***F*** = 40 kg x 0.92 m s^{-2} ***F*** = 37 N	**2**
4(c)(i)	Use of trigonometrical relationship (200 cos 20°) to resolve force (1) ***F*** = 152 N (1) Example of calculation Horizontal component of force = 200 N x cos 20° = 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) Example of calculation 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 $\times$ 9.81 kg m s^{-2} $= 2.98 \times 10^7$ 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** $a = F/m$ $= 4.2 \times 10^6$ 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. Opposite 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. car exerts upward/opposite force on Earth (the different points) (1) gravitational and 12 000 N/equal (the identical points) (1) [no ue]	**2**
	Total for question	**8**

Question Number	Answer	Mark
7a	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)	**Max 6**
7b	repeat and mean (one mark max for any relevant quantity/result) (1) Precaution - a precaution relating to experimental procedure (1)	**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) Example of calculation 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)** Example of calculation 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)** Example of calculation 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)** Example of calculation $F = 6\pi\eta rv$ = 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**