Question			Expected Answers	Marks	Additional Guidance
1	(a)		… ***immediately*** *after jumping* Only force is the weight/drag = 0/net force = weight acceleration = g/9.8(1 m s^{-2}) (Allow '*mg*' for weight. Do not allow 'gravity' for weight.) … ***before*** *terminal velocity is reached* Any **<u>two</u>** from: Drag increases (with speed) /drag $\propto$ speed^2 Net or resultant or total force decreases / weight > drag Acceleration is less than g … ***at*** *terminal velocity* weight = drag / net force = 0 acceleration = 0 /<u>constant</u> speed or velocity (AW)	B1 B1 B1 B1 B1 B1 B1	**Alternatives** accepted for *drag* are: friction/air resistance **Allow**: 'Has acceleration of free-fall/due to gravity' as alternative for second B1 mark **Allow**: velocity instead of speed. **Allow**: 'drag $\propto$ speed' as BOD. **Allow**: Acceleration decreases **Allow**: upward force(s) = downward force/'forces balanced'
	(b)		(Transformed to) heat/thermal (energy)	B1	**Not**: 'Friction'/sound
	(c)		Any **<u>two</u>** from: 1. The terminal velocity increases 2. Initial gradient/slope is the same/equal to g 3. Time taken to reach terminal velocity is longer	B1 × 2	**Allow**: Initial acceleration is the same/g/9.8(1 m s^{-2})
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	*N* is normal to the ramp (judged by eye) *F* is parallel <u>and</u> up the ramp	B1 B1	Allow marks even if the labels *N* and *F* are omitted
		(ii)	$F = W\sin\theta$	B1	
	(b)	(i)	Expected answer: '*For equilibrium of an object the sum of clockwise moments about a point = sum of anticlockwise moments about the same point*.' clockwise moment(s) = anticlockwise moment(s) Reference to one of the moments taken about a <u>point</u>/'equilibrium'/sum (or total or net or Σ) mentioned once	 M1 A1	 **Note**: The term '*clockwise*' to be included and spelled correctly to gain the M1 mark **Note**: 'net moment = 0' is equivalent to the M1 mark **Note**: If M1 is lost for incorrect spelling of 'clockwise', then allow this A1 mark
		(ii)	$200\times12 = F\times75$ $F = 32$ (N)	C1 A1	**Note**: Bald answer of 32 (N) scores 2/2 marks
		(iii)	$p = \dfrac{32}{6.0\times10^{-5}}$ pressure = 5.3×10^5 (Pa)	C1 A1	Possible ecf **Note**: Bald answer of 5.3×10^5 (Pa) scores 2/2 marks
		(iv)	(Pressure is) greater because the force/*F* is larger (to provide the same moment)	B1 B1	
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)		time = $6.9 \times 3.16 \times 10^7$ (= 2.18×10^8 s) average speed = $\frac{5.0 \times 10^{12}}{6.9 \times 3.16 \times 10^7}$ average speed = 2.29×10^4 or 2.3×10^4 (m s^{-1})	C1 A1	**Allow**: 1 mark for $5.0 \times 10^{12}/6.9 = 7.2(46) \times 10^{11}$ (m y^{-1}) **Allow**: 1 mark for $\frac{5.0 \times 10^{12}}{3.16 \times 10^7} = 1.58 \times 10^5$ (m s^{-1})
	(b)		distance = 0.70×200 (= 140 mm) or KE = ½ × $4.0 \times 10^{-6} \times 6100^2$ (= 74.4 J) work done = change in KE $F \times (0.70 \times 10^{-3} \times 200) = \frac{1}{2} \times 4.0 \times 10^{-6} \times 6100^2$ *F* = 530 (N) ---------- or ---------- *F* = *ma* $a = \frac{6100^2}{2 \times (0.70 \times 10^{-3} \times 200)}$ (=1.33×10^8) *F* = $4.0 \times 10^{-6} \times 1.33 \times 10^8$ *F* = 530 (N)	C1 C1 A1 C1 C1 A1	**Note**: Bald answer scores 3/3 marks **Note**: 0.53 (N) scores 2/3 because of 10^n error in distance 1.06×10^5 (N) scores 2/3 because '200' not taken into account 106 (N) scores 1/3 because '200' missed out and 10^n error
			Total	**5**	

Question			er	Marks	Guidance
4	(a)		Drag increases with speed (ORA) / drag $\propto$ speed^2	B1	
	(b)		Galileo dropped different mass balls / rolled different mass balls (down a ramp) Balls hit the ground / reached the bottom (of ramp) at the same time (Galileo -) All objects fall with the same acceleration <u>and</u> (Aristotle -) Heavy / massive objects fall faster / quicker (than light objects)	B1 B1 B1	**Allow** object / trolley instead of ball
	(c)	(i)	(The two forces are weight and drag) weight = drag	B1	**Not** 'gravity' for weight **Allow**: weight = drag + upthrust
		(ii)	When the parachute is opened, drag increases / drag is greater than the weight Drag decreases as the speed decreases / net force decreases The (magnitude of the) deceleration decreases (between 50 m s^{-1} and 4 m s^{-1}) (At 4 m s^{-1}) deceleration or acceleration = 0	B1 B1 B1 B1	
			Total	**9**	

Question			Answer	Marks	Guidance
5	(a)		Object moves into region 3 (net) force to left / 1 (N) to the left / 8 (N) > 7 (N) and (net) force down / 2 (N) down / 12 (N) > 10 (N)	M1 A1	 **Allow** use of labelled arrows, e.g ↓ 2 (N)
	(b)		(When an object is in equilibrium the) sum of clockwise moments (about a point) = sum of anticlockwise moments (about the same point)	B1	**Allow**: summation sign Σ
	(c)		$50 \times 46 = \text{weight} \times 14$ weight = 164 (N) mass = 164/9.81 mass = 16.7 (kg) or 17 (kg)	C1 C1 A1	 Possible ecf for weight calculated. **Note**: Using '$50 \times 46 = \text{weight} \times 32$' gives an incorrect weight of 71.9 (N). However, 1 mark can be scored through ecf for a mass of 7.3 (kg) **Allow**: 3 marks for 'weight = 160 N, mass = 16.3 kg or 16 kg'
			Total	**6**	

Question			Answers	Marks	Guidance
6	(a)		A straight line through the origin	B1	**Ignore** graph after 0.5 s.
	(b)		The speed (of the car) is constant	B1	**Note**: This can only be scored if **(a)** is correct
	(c)		The distance travelled by the car after the brakes are applied until the car stops	B1	**Note**: Must have reference to car 'stopping' to score the mark
	(d)				**Must use tick or cross on Scoris to show if the mark is awarded**
			Mass (of car) (½ $mv^2 = Fx$, hence braking) distance $\propto$ mass	M1 A1	**Allow**: weight (of car) **Not**: 'distance increases with mass' **Allow**: distance $\propto m$
			Speed / velocity (of car) (½ $mv^2 = Fx$, hence braking) distance $\propto$ speed^2	M1 A1	**Not**: 'distance increases with speed' **Allow**: distance $\propto v^2$
	(e)				**Must use tick or cross on Scoris to show if the mark is awarded**
			Increases time (of impact / to slow down) / increases the distance (travelled by the driver)	B1	
			Smaller deceleration / acceleration	B1	**Not**: 'slow down acceleration'
			Force is smaller because $F = ma$ and a is smaller or force is smaller because $F = E_k/x$ and x is bigger or force is smaller because $F = \frac{\Delta p}{\Delta t}$ and Δt is bigger	B1	**Allow**: $E_k = Fx$ and x is bigger **Not**: Prevent crashing into windscreen / steering wheel
			Total	**10**	