Question			Answers	Marks	Guidance
1	(a)		moment = force × perpendicular distance from point / pivot ✎**The term *perpendicular* to be included and spelled correctly to gain the B1 mark**	B1	**Must use tick or cross on Scoris to show if the mark is awarded**
	(b)		Net force = 0 Net moment / torque = 0	B1 B1	**Not**: 'All forces are equal' or 'forces are balanced' or 'total forces up = total forces down' **Allow**: 'sum of clockwise moments = sum of anticlockwise moments'
	(c)	(i)	The point where the weight (appears) to act	B1	**Not**: 'The point where gravity acts' or 'point where mass acts/is concentrated'
		(ii)	moment = (0.150 × 18) + (0.460 × 30) moment = 16.5 (N m)	C1 A1	**Allow**: 2 sf answer of 17 N
		(iii)	1 Same / equal to 16.5 (N m) / equal to clockwise moment 2 (perpendicular) distance between elbow and (the line of action of) *F* decreases or (the vertical force) $F\cos\theta$ is the same or $F\cos\theta$ = 412.5 or $F \propto \frac{1}{\cos\theta}$ Hence the force increases	B1 M1 A1	Possible ecf
			Total	**9**	

Question			Answers	Marks	Guidance
2	(a)		mass = $\frac{590}{9.8(1)}$ (= 60 kg)	B1	**Allow**: weight = 60 × 9.8(1) **Allow**: 60 × 9.8(1) = 588 (N) or 60 × 9.8(1) = 590 (N)
	(b)		net force = 60 × 0.50 (= 30 N) *R* = 590 + 30 *R* = 620 (N)	 C1 A1	 **Allow**: 1 mark for '590 – 30 = 560 (N)'
	(c)		resultant force = 0 / '*a* = 0 and *F* = *ma* = 0'	B1	**Not**: Acceleration = 0 or 'forces are balanced'
	(d)		weight > *R* (for deceleration) / *R* = 590 – 60*a* / *R* = *mg* -*ma* Hence *R* decreases	M1 A1	**Allow**: *W* or *mg* for 'weight'
			Total	**6**	

3	Expected Answers	Marks	Additional Guidance
a	kinetic energy = ½ × mass × speed^2	B1	**Allow** KE = ½ mv^2, where m = mass and v = speed **Allow** velocity instead of speed **Not**: KE = ½ mv^2 on its own
b(i)	initial KE = ½ × 3.0 × 10^{-2} × 200^2 (= 600 J) final KE = ½ × 3.0 × 10^{-2} × 50^2 (= 37.5 J) Loss in KE = 600 – 37.5 Loss in KE = 562.5 (J) ≈ 560 (J)	C1 C1 A1	 **Special case**: 1 mark for 'KE = ½ $m\underline{v}^2$ ... loss in KE = (½ × 3.0 × 10^{-2} × 200 - ½ × 3.0 × 10^{-2} × 50 =) 2.25 (J)' **Note:** No marks for 337.5 (J) when Δv used in the KE equation (½ × 3.0 × 10^{-2} × 150^2 = 337.5 J)
b(ii)	work done = (loss in) KE / $a = (v^2 - u^2)/2s$ F × 1.5 × 10^{-2} = 562.5 / a = (-) 1.25 × 10^6 force = 3.75 × 10^4 (N)	 C1 A1	 Possible ecf from **(b)(i)** **Allow**: A 2 sf answer of either 3.8 × 10^4 (N) or 3.7 × 10^4 (N)
	Total	**6**	

4	Expected Answers	Marks	Additional Guidance
a	…incorrect Mass (of the particle) increases (as it approaches speed of light)	M1 A1	**In question 5, use tick or cross on Scoris to show if the mark is awarded** **Not**: mass *changes*
b	….correct KE is changed into (G)PE or (G)PE is changed into KE or change in KE = change in (G)PE (AW)	M1 A1	 **Note**: This mark is for stating the transfer of energy between kinetic and (gravitational) potential
c	…incorrect Weight is equal to drag / air resistance / friction (and not acceleration of free fall)	M1 A1	Allow **alternative** response: ……. incorrect M1 Acceleration and weight are not the same quantities (AW) A1
d	…incorrect The technique is trilateration ✎ **The term *trilateration* to be included and spelled correctly to gain the A1 mark**	M1 A1	 **Note** 1 mark if ‘trilateration’ is misspelled but candidate has mentioned that the statement is incorrect
	Total	**8**	

5	Expected Answers	Marks	Additional Guidance
a	A pair of <u>equal</u> and <u>opposite</u> forces (with their lines of action separated by a distance) ✎ **The term *opposite* to be included and spelled correctly to gain mark**	B1	**Must use tick or cross on Scoris to show if the mark is awarded** No mark can be scored if there is no reference 'opposite'. (Allow 'opposing')
b(i)	moment = force × <u>perpendicular</u> distance from pivot / axis / point	B1	
b(ii)	(clockwise moment =) 20 × 0.60 <u>and</u> (anticlockwise moments =) 10 × 0.20 + 30 × 0.30 (Not in equilibrium because) clockwise moment ≠ anticlockwise moment / clockwise moment > anticlockwise moment / 12 (Nm) > 11 (Nm) / 12 (Nm) ≠ 11 (Nm)	M1 A1	**Allow** a correct moments equation involving all three forces
	Total	**4**	

Question			Expected Answers	Marks	Additional Guidance
6	(a)		$W = mg$ weight $= 1.50 \times 9.81 = 14.72$ (N) or 14. 7 (N) or 15 (N)	B1	**Allow**: Use of 9.8 (m s^{-2}) **Allow**: Bald 15 (N); but **not** '1.50 $\times$ 10 = 15(N)'
	(b)	(i)	Net / resultant force (on **B**) is less / (net) force (on **B**) is less than its weight / there is tension (in the string) / there is a vertical / upward / opposing force (on **B**)	B1	**Note**: Must have reference to force
		(ii)	$s = ut + \frac{1}{2}at^2$ and $u = 0$ $1.40 = \frac{1}{2} \times 1.09 \times t^2$ t = 1.60 (s)	C1 C1 A1	**Allow**: 2 marks for 1.75/1.09' if answer from **(iii)** is used **Allow**: 2 sf answer **Allow**: 2 marks if **2.80 m** is used; time = 2.27 (s)
		(iii)	$v^2 = 2 \times 1.09 \times 1.40$ / $v = 0 + 1.09 \times 1.60$ v = 1.75 (m s^{-1}) / v = 1.74 (m s^{-1})	C1 A1	Possible ecf **Allow**: 1.7 or 1.8 (m s^{-1})
		(iv)	change in velocity = 2.47 + 1.50 (= 3.97 m s^{-1}) acceleration = $\frac{3.97}{0.030}$ acceleration = 132 (m s^{-2})	C1 A1	Ignore sign for change in velocity **Allow**: 130 (m s^{-2}) --- **Special case:** acceleration = $\frac{2.47 - 1.50}{0.030} = 32.3$ or 32 (m s^{-2}) scores 1 mark
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
7	(a)		mass = $\underline{140 \times 3.0}$ (= 420 kg)	B1	**Allow**: $\frac{420}{3.0} = 140$ (reverse argument)
	(b)	(i)	total mass = 500 + 560 + 420 (= 1480 kg) total weight = 1480 × 9.8(1) / total weight = 14520 (N) net force = 1480 × 1.8 / net force = 2664 (N) tension = 14520 + 2664 tension = 1.7(2) × 10^4 (N)	C1 C1 C1 C1 A0	**Note**: Omitting one of the masses – can score maximum of 3 Omitting two masses – can score maximum of 2 **Examples:** 3 marks if mass of cable is omitted tension = 1908 +10400 = 1.23 × 10^4 (N) 2 marks if mass of cable and people are omitted tension = 900 + 4905 = 5.8 × 10^3 (N) **Note**: 4 marks for 'tension = $(m(g+a) =)$ 1480 × (9.81 + 1.8)'
		(ii)	stress = $\frac{1.72 \times 10^4}{3.8 \times 10^{-4}}$ / stress = $\frac{(b)(i)}{3.8 \times 10^{-4}}$ stress = 4.5(3) × 10^7 (Pa)	C1 A1	Possible ecf from **(i)** **Note**: A tension of 1.7 × 10^4 (N) gives an answer of 4.4(7) × 10^7 (Pa)
			Total	**7**	