1)

a	A pair of equal and opposite 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 × perpendicular distance from pivot / axis / point	B1	
b(ii)	(clockwise moment =) 20 × 0.60 and (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**	

2)

(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**	

3)

(a)		torque of a couple = one of forces × perpendicular distance (between forces)	**B1**	**Not**: 'force × perpendicular distance'
(b)		Torque and moment are to do with 'distance multiplied by force'	**B1**	
(c)	**(i)**	moment = 6.0 × 0.40 moment = 2.4 (N m)	**B1**	
	(ii)	Weight / force acts through the pivot Or (perpendicular) distance from pivot is (reduced to) zero (wtte)	**B1**	**Allow**: weight is 'vertically below' / 'directly below' the pivot Reference to pivot / point **P** (wtte) is essential
(d)		Any three from: 1. (Suspend plate from a point and then) mark a vertical line on the plate (wtte) 2. Plumb line / 'pendulum' (used to find the vertical line) 3. Hang from another point / place (and draw another vertical line) (wtte) 4. Where the lines intersect gives position of centre of gravity (wtte)	**B1×3**	**Note**: For 1st point accept 'mark line of string' **Allow**: 1 mark for 'By trial and error find a position where the plate balances'
(e)		(sum of) clockwise moment(s) = (sum of) anticlockwise moment(s) $(18\times0.14)+(60\times0.32)=0.035F$ $F \approx 620$ (N)	**C1** **C1** **A1**	**Not**: 'CWM = ACWM' **Allow**: working in consistently in cm **Note**: Bald answer scores 3 marks **Allow**: 1 mark for 21.72 (N m) or 2172 (N cm)
		Total	**10**	

4)

(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 × 46 = weight × 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 × 46 = weight × 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**	

5)

a(i)	torque = 4.0×0.03 torque = 0.12 (N m)	C1 A1	 **Note**: An answer of 12 scores 1 mark (because cm not converted into m) **Allow**: Full marks for if the centi prefix added; that is 12 N cm **Allow**: 2 marks for a bald 0.12 (N m)
a(ii)	 (total moment =) $(x + 0.03) \times 4.0 - 4.0x$ (total) moment = 0.12 (N m) It is the same as the torque (of the couple) / same as **(a)(i)**	 M1 A1 B1	**Condone** the use of 'N cm' in **a(ii)** **Allow**: Equation with x value of 0.06 (m) or 6 cm **Special case**: 1 mark for (anticlockwise moment =) $4.0x$ or (clockwise moment =) $[x + 0.03] \times 4.0$ seen anywhere on the script **Not**: '0.12 (N m)'
b	Net / total / resultant force = 0 Net / total torque / moment = 0	B1 B1	**Not**: 'forces are balanced' or 'force up = force down' **Allow**: clockwise moment(s) = anticlockwise moment(s)
c(i)	$\rho = \frac{M}{V}$ / density = $\frac{45}{0.600 \times 0.600 \times 0.050}$ density = 2.5×10^3 (kg m^{-3})	C1 A1	 **Allow**: 2 marks for a bald answer of 2.5×10^3 (kg m^{-3})
c(ii)	clockwise moment = anticlockwise moment **or** (weight =) 45×9.81 / (weight =) 441.45 $(45 \times 9.81) \times 0.150 = F \times 0.600$ F = 110 (N)	C1 C1 A1	 **Allow**: 3 marks for a bald 110 (N) **Allow**: 2 marks for 11.25 – mass of 45 kg not changed to N
	Total	**12**	

6)

a	**i**	work (done) / (elastic potential) energy	B1	**Not:** heat / gravitational potential energy / kinetic energy
	ii	displacement / distance	B1	
b		Any <u>two</u> from: • Torque (of a couple) • Moment (of a force) • Work (done) / energy	B1×2	**Not**: 'Couple' for 'torque' **Allow**: PE / KE
		Total	**4**	

7)

(a)	(i)	Two equal but opposite forces	B1	
	(ii)	torque = one of the forces × <u>perpendicular</u> distance between the forces	B1	**Use tick or cross on Scoris** ***perpendicular*** must be spelled correctly to gain the mark
(b)	(i)	It will rotate / spin / turn Rotation is clockwise / (continue) to travel from left to right/ the rotational speed increases (with time)	B1 B1	
	(ii)	It will accelerate The idea that acceleration is to the right / Suggestion that satellite will 'turn'	B1 B1	**Allow**: 'speed up' / 'speed increases' / 'velocity increases' / 'move faster'
		Total	**6**	

8)

(a)	**(i)**	*N* is normal to the ramp (judged by eye) *F* is parallel and 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 point/'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)	$p = \frac{32}{6.0\times10^{-5}}$ 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**	

9)

(a)		A point where the (entire) weight of the object (appears to) act	B1	**Not**: 'where the weight of an object acts'
(b)		moment of force = force × perpendicular distance (of line of force) from point/axis/pivot/fulcrum	B1	
(c)	**(i)**	net force = 0 net moment = 0 or net torque = 0	B1 B1	**Allow**: (For this rod) upward force = (sum of the) forces down **Allow**: (For this rod sum of) clockwise moment(s) = (sum of) anticlockwise moment(s)
	(ii)	Evidence of $0.12x$ or $0.35(0.50 - x)$ $0.12x = 0.35(0.50 - x)$ $x = \frac{0.35\times0.50}{0.12+0.35}$ $x = 0.37$ (m)	C1 C1 A1	
	(iii)	force = 0.47 (N)	B1	
		Total	**8**	

10)

(a)		$5.1\times\cos40\times0.75$ or $d\times1.2\times g$ $5.1\times\cos40\times0.75=d\times1.2\times9.81$ $d=\frac{5.1\times\cos40\times0.75}{1.2\times9.81}$ d = 0.25 (m)	C1 C1 A1	**Allow** 2 marks if sine of the angle is used instead of cosine; this gives an answer of 0.21 (m). **Allow** use of 9.8 (m s^{-2}) **Note**: '5.1 × 0.75 = d × 1.2 × 9.81; d = 0.32.. (m)' scores 1 mark because of the first C1
(b)		The string provides a horizontal force (to the left), hence there must be a horizontal force at the support (to the right, therefore the force at the support cannot be vertical). (AW) Or If the force was just vertical at the support then the object would move to the left (and so will not be in equilibrium). (AW) Or Force at support is at an angle and passes through the point of intersection (of the lines of action) of the weight and the tension. (AW)	B1	**Allow** Tsin40 for the horizontal force
		Total	**4**	

11)

a	**i**	mass = 2400 × (0.80 × 1.2 × 15) / mass = 3.46 × 10^4 (kg) weight = 3.46 × 10^4 × 9.81 weight = 3.4 × 10^5 (N)	C1 A1	
	ii	pressure = 3.4 × 10^5/(15 × 0.80) pressure = 2.8 × 10^4 (Pa)	C1 A1	Possible ecf from **(a)(i)**
b	**i**	Net moment is zero (about any point / axis).	B1	**Allow** 'clockwise moment(s) = anticlockwise moment(s)' **Allow** net torque is zero
	ii	The force exerted (at **X**) decreases. Correct explanation, e.g: The moment must be the same (about the other wall / pivot) and the distance (from it) has increased.	M1 A1	**Allow** 'force × (perpendicular) distance' for moment
		Total	**7**	

12)

(a)	The resultant force is zero There is no acceleration	B1 B1	**Not** 'in equilibrium' **Not**: constant velocity; since this is in the question
(b)	(moment of a force =) force × perpendicular distance from point / pivot	B1	**Must use ticks on Scoris to show where the marks are awarded** ***'perpendicular'*** must be spelled correctly to gain the mark.
(c)	Forces are in the same direction / The forces are not opposite / The forces are not equal (in magnitude)	B1	
(d)	(clockwise moments =) (720 × 0.40) + (180 × 0.60) or 396 (N m) sum of clockwise moments = sum of anticlockwise moments 396 = 1.3 F F = 300 (N)	C1 C1 A1	**Allow**: 2 marks for '720 × 0.40 = 1.3 × F, F = 221 (N)' or 180 × 0.60 = 1.3 × F, F = 83 (N)' **Note**: Answer is 305 (N) to 3 sf and 304.6 (N) to 4 sf
(e)	The force at **X** decreases The force at **Y** increases / greater clockwise moment / F_X + F_Y = 900 (N)	B1 B1	**Allow**: the rider's centre of gravity / mass moves further from **X**
	Total	**9**	