Question			Answer	Marks	Guidance
1	a		pressure and stress or pressure and Young modulus or stress and Young modulus or moment (of a force) and torque (of a couple)	B1	**Allow** other correct combinations **Allow** the following: • e.m.f. and p.d. • Any two from frequency, activity, decay constant and Hubble constant because of the s^{-1} **Ignore** any units given (even if incorrect) **Special case**: Allow quantities with no units, e.g. strain and efficiency. **Not** any combination of length, distance and extension
	b	i	*x*-component = 6.0 (N) and *y*-component = 2.0 (N)	B1	**Allow** 1 sf answers **Allow** tolerance $\pm$ 0.1 N **Not** *x*-component = 2.0 (N) and *y*-component = 6.0 (N)
		ii	resultant components are 8.0 (N) and 5.0 (N) $F^2 = 8.0^2 + 5.0^2$ force = 9.4 (N)	C1 C1 A1	**Allow**: 1 sf values for this C1 mark Possible ecf from **(b)(i)** with *x*-components = 2 + **b(i)** and *y*-component = 3 + **b(i)**. **Note**: Answer is 9.43 to 3sf **Not** an answer left in square root form, e.g $\sqrt{89}$ **Allow** full credit for a scale drawing; marks awarded as below: • A dot / cross / mark at 8.0,5.0 ($\pm$ 0.1) C1 • Line drawn from 0,0 to 8.0,5.0 C1 • force = 9.4 $\pm$ 0.1 (N) A1
	c	i	Down	B1	**Allow** a downward arrow on Fig. 2.2

Question			Answer	Marks	Guidance
		ii	Horizontal component of the velocity is constant There is no <u>horizontal</u> <u>force</u>	B1 B1	**Allow**: There is no horizontal <u>acceleration</u> **Allow**: Weight / *g* has no horizontal component or Weight / *g* is 90° to the horizontal or Weight / *g* is vertical or 'there is <u>only</u> a vertical force' (**Not** 'gravity' for 'weight'; allow 'force of gravity')
		iii	Any <u>two</u> from: • It decreases from **X** to **Y** • It is zero at **Y** / It has the same magnitude at **X** and Z • It increases from **Y** to **Z** • It is positive from **X** to **Y** and negative from **Y** to **Z** (or vice versa)	B1 × 2	**Ignore** description in terms of acceleration or deceleration **Allow** it changes sign / direction from **X** to **Z**
			Total	**10**	

Question			Answer	Marks	Guidance
2	a	i	Length from **A** to **B** = 8.0 (cm) displacement = 400 (km) or time = 1500 (s) average velocity = $400 \times 10^3/1500$ average velocity = 270 (m s^{-1})	C1 C1 A1	**Allow** $\pm$ 0.1 cm Possible ecf within the calculation for an incorrect value for length **AB**. **Note** no credit if distance is used.
		ii	(The average speed is different because) the <u>distance</u> (travelled) is different / not the same / greater than the <u>displacement</u>	B1	
	b	i	distance = $2 \times \pi \times 4.2 \times 10^8$ speed = $\frac{2 \times \pi \times 4.2 \times 10^8}{1.5 \times 10^5}$ speed = 1.8×10^4 (m s^{-1})	C1 A1	**Note**: Answer to 3 sf is 1.76×10^4 (m s^{-1}) **Not** 5600π (m s^{-1})
		ii	($0 = u^2 - 2as$) $(1.3 \times 10^3)^2 = 2 \times a \times 470 \times 10^3$ (Any subject) $a = \frac{(1.3 \times 10^3)^2}{2 \times 470 \times 10^3}$ (*a* must be the subject) acceleration = 1.8 (m s^{-2})	C1 C1 A1	**Allow** full credit for '$mgh = ½\ mu^2$' approach **Ignore** signs **Allow**: 2 marks for 1.8×10^n; $n \neq 0$
			Total	**9**	

Question			Answer	Marks	Guidance
3	a		$F \rightarrow$ kg m s^{-2} **or** $A \rightarrow m^2$ and $v \rightarrow$ m s^{-1}	M1	**Alternative**: (units on rhs:) kg $m^{-3} \times m^2 \times m^2$ s^{-2} **or** (unit for lhs:) = kg m s^{-2} M1
			Manipulation leading to $k \rightarrow$ kg m^{-3}	M1	Manipulation leading to same units on both sides M1
			$k \rightarrow$ kg m^{-3}	A0	**Allow** other correct methods
	b	i	Arrow directly opposite to *D* on Fig. 6.1	B1	**Ignore** position and length of arrow
		ii	The ball is not at terminal velocity, since *D* and *W* are not (directly) opposite / The ball is not at terminal velocity because there is a net force	B1	**Not** *D* and *W* are at 90°
		iii	It is travelling (vertically) upwards	M1	
			It will slow down / It decelerates / It accelerates (vertically) downwards / There is a net downward force / drag opposes motion	A1	
	c		At the start, acceleration = *g* (because there is no drag)	B1	**Allow** 9.8(1) m s^{-2} / acceleration of free fall / acceleration due to gravity (**Not** 'gravity' on its own) **Not** rate of acceleration is *g*
			Drag increases (as its speed increases / accelerates)	B1	
			net force decreases or net force < weight	B1	
			(As it falls) acceleration decreases / (As it falls) acceleration < *g*	B1	**Not** 'rate of acceleration decreases' unless it is qualified or 'acceleration slows down'
			Total	**10**	

Question			Answer	Marks	Guidance
4	a	i	mass = $2400 \times (0.80 \times 1.2 \times 15)$ / mass = 3.46×10^4 (kg) weight = $3.46 \times 10^4 \times 9.81$ weight = 3.4×10^5 (N)	C1 A1	
		ii	pressure = $3.4 \times 10^5/(15 \times 0.80)$ 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**	

Question			Answer	Mark	Guidance
5	(a)	(i)	*N* & *W* act on the same body / Newton's 3rd Law forces should act on different bodies *N* & *W* are different types (of force) / are not same type	B1 B1	**Allow:** 3rd law pair to W acts on (centre of)Moon 3rd law pair to N acts on surface of Moon **Allow:** *N* is electromagnetic/electrostatic/electrical/contact *W* is gravitational. **Allow:** Paired forces should be of the same type **Ignore** a general statement of Newton's 2nd or 3rd law
		(ii)	Equal to / same as *W* acting on (the centre of) the Moon	B1	Do not allow 'acts on **surface** of Moon Diagram is not sufficient for this mark
	(b)		Clear use of vertical motion with downward acceleration **and** horizontal motion at constant velocity vertically $0 = (u\sin\theta)t - \frac{1}{2}g_M t^2$ $t = \frac{2u\sin\theta}{g_M}$ horizontaly $x = u\cos\theta \times \frac{(2u\sin\theta)}{g_M}$ $x \propto \frac{u^2}{g_M}$ –	B1 M1 A1 A0	If sin θ and cos θ are confused allow max 1/3. **Allow:** use of *a* for g_m **Allow:** determination of time to max height using $v=u+at$ Then total time = 2 x time to max height (M1) **Allow** use of 9.81 instead of g_m
			Total	**6**	

Question			Answers	Marks	Guidance
6	(a)		$5.1\times\cos 40\times 0.75$ or $d\times 1.2\times g$ $5.1\times\cos 40\times 0.75 = d\times 1.2\times 9.81$ $d = \dfrac{5.1\times\cos 40\times 0.75}{1.2\times 9.81}$ 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**	