Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			**B**	1	**Examiner's Comments** This question was made more challenging by not including the weight of the beam on the diagram. The correct approach is to take moments about the left hand end of the beam. Omitting the weight of the beam gives N1 = 0.5W and N2 = 1.5 W. When the weight of the beam is included, (2L x W) + (3L x 2W) = (4L x N2), giving N2 = 2 W and N1 = 2 W, i.e. option B.
			Total	**1**	
2	a		Moment = 5 × 9.81 × 0.6 (=29.4) 29.4 N m	C1 A1	**Allow** 29 2sf/30 1sf **Examiner's Comments** Candidates performed well on this question as they correctly applied the equation moment = force x perpendicular distance from the pivot to calculate the moment as 29.4 Nm and most also gave the correct unit for moment as Nm.
	b		perpendicular (or horizontal) distance between the line of action of the weight and the hips is reduced AW the moment is reduced / very small (so) the force (on the spine) is reduced	B1 M1 A1	**Allow** fulcrum/pivot/turning point for hips **Allow** Keeps the load close to the hips/point H/ reduces (perpendicular) distance to the hips/point H **Allow** turning effect **Ignore** ref. to position of the centre of mass changing **Ignore** ref. to the knees/elbows as the pivot **Examiner's Comments** There were not many successful responses for this question and many were given 0 marks. Most responses were often vague and unspecific

					descriptions of a change in the centre of mass, or a distribution of the weight of the box. Most candidates did not establish that by bending the knees, the perpendicular distance to the pivot/hips decreased. Hence the moment about the pivot/hips would be reduced, which in turn reduced the force acting on the spine, resulting in less damage. Some candidates did describe that the moment about the pivot/hips would be reduced by bending the knees. However, a significant number of candidates would then follow this by explaining that there would be 'less stress' on the spine, rather than less force acting on the spine.
			Total	**5**	
3	a	i	the point where the <u>weight</u> of the prism appears to act	B1	**Allow** gravitational force / gravity force for weight **Not** gravity, mass **<u>Examiner's Comments</u>** This definition was not clearly stated by the majority of candidates. Many candidates incorrectly referred to mass. It was expected that candidates would use the correct scientific term and refer to the weight (of the prism). Examiners also did not credit answers where the term 'gravity' on its own was used. For example, 'the point where gravity is said to be acting' did not gain credit since it was not the correct scientific term and in effect was repeating the stem of the question. **Misconception** Candidates appear not to understand the definitions and the difference between the two specification terms 'centre of mass' and 'centre of gravity' [specification reference 3.2.3d].

		ii	One straight line drawn from mid-point of one side (by eye) to opposite apex At least two straight lines, each drawn from mid-point of one side (by eye) to opposite apex, and C (labelled) in the range 4.8 cm to 5.2 cm from the centre of PQ candidate's vertical distance from PQ × 0.05 = in the range 0.24 m to 0.26 m	C1 M1 A1	**Not** 0.25 ÷ 0.05 **<u>Examiner's Comments</u>** This question required candidates to show how they would obtain an answer. It appeared that many candidates incorrectly started with the answer and then marked on the diagram the position of the centre of gravity C. The majority of the candidates understood that C would lie on a straight line from the mid-point of the horizontal surface to the apex of the triangle. Few candidates drew line from the mid-points of the other two sides to the opposite corners. Few candidates used the scale to show that C was 0.25 m.
	b	i	Sum of the forces / net / resultant force (in any direction) = 0 Sum of the moments / net / resultant moment = 0 Sum of the moments / net / resultant moment <u>about any point</u> = 0	B1 M1 A1	**Allow** (total) upward force = (total) downwards force **Allow** (total) clockwise moment = (total) anticlockwise moment **Allow** torque for moment **<u>Examiner's Comments</u>** The majority of the candidates understood that resultant force was zero and that the resultant moment was also zero. Few candidates stated that the result force would be zero **in any direction** and the resultant moment would be zero **about any point.**
		ii	Weight = 3.98 × 9.81 OR 39 3.98 × 9.81 × 0.25 = F × 0.75 13 (N)	C1 C1 A1	**Allow** 3.98 × 10 OR 40 (since change in final answer is negligible) **Allow** two marks for 1.3 (omits g) **<u>Examiner's Comments</u>** The majority of the candidates correctly calculated the weight of the prism. It is expected that the value of g should be the value given on the data sheet. Using the principle of moments was

					generally answered well by higher scoring candidates. A number of candidates incorrectly determined a distance of 0.50 m (0.75 - 0.25). High scoring candidates usually showed clear working. **Assessment for learning** Candidates should practise answering calculation type questions. Candidates should: 1. Write down the equation they are going to use 2. Substitute the data into the equation 3. Consider the units 4. Rearrange the equation 5. Evaluate the answer 6. Check that the answer is sensible. **OCR support** The Maths skills handbook: Physics has guidance on algebra, as well as a range of maths skills.
			Total	**10**	
4			Suspend object (freely) and mark vertical (down) Repeat(s) (from different point) and reference to intersection of verticals Plumb line/ plumb bob /AW	B1 B1 B1	Allow methods with unstable equilibrium e.g. balance shape on a pin/finger for 1 mark max Accept spirit level **Examiner's Comments** This question was answered well by the majority of candidates, especially those that mentioned a good method of showing where the vertical was. Explicit use of the term 'plumb-bob' or 'plumbline' was not required i.e. 'mass

					on a string' or 'pendulum' or 'string with an object on the end' were all perfectly acceptable alternate wordings. Methods that relied on balancing the 2-D shape horizontally on a point could only score a maximum of 1 mark, even though it is a viable way of checking the results of the more detailed and expected procedure. **Examiner's Comments** In Question 19 (b) (i), many candidates spotted the need to calculate the GPE required to raise the bridge using the relationship GPE = *mgh* although there was some confusion about the value of *h*. The centre of mass goes from a position 1.3 m below the top of the grey boxes to a position 6.3m above those same grey boxes, making the total value of *h* 7.6 m. Once the candidates had calculated the GPE, the successful ones divided by the time taken to lift the platform i.e. 90 seconds. Candidates that forgot the extra 1.3 m but otherwise completed the calculation correctly scored 1 mark out of the 2 available. No other distances were given credit.
			Total	**3**	
5			B	1	
			Total	**1**	
6			A	1	**Examiner's Comments** Candidates performed less well on this question as they either interpreted that since the forces acting on the object in equilibrium were equal and opposite the object was at rest, or that the pair of forces were an interaction

					pair of forces, so B and C were the most common distractors.
			Total	**1**	
7			B	1	**Examiner's Comments** This question was generally answered well as most candidates correctly resolved *T,* tension to determine an expression for *W*.
			Total	**1**	
8			C	1	**Examiner's Comments** This question assessed candidates understanding of forces acting in a system in equilibrium with most candidates applying their knowledge of forces as vectors. This meant that most candidates answered C correctly.
			Total	**1**	
9	a	i	(area of shaded region =) 1.9 × 6.0 or 11.4 (m^2) (volume of air in 3.0 s =) 11.4 × 3.0 × 12 (mass of air = 11.4 × 3.0 × 12 × 1.2) mass of air = 492(.48) (kg)	C1 C1 A1	**Allow** volume found in one second leading to mass per second multiplied by 3 for 2nd and 3rd mark **Note**: volume of air is 410 (m^3)
		ii	Δp = 12 × 490 or 5900 (kg ms^{-1}) (force = Δp / Δt = 5900/3.0) *F* = 2000 (N)	C1 A1	Expect to see mass of 490, 492, 492.5, 492.48 **Note** answer is 1970 to 3 SF using 492.48 **Note** answer is 1960 to 3 SF using 490 **Examiner's Comments** Candidate's answers to this part were either jumbled or grounded in incorrect physics.

					This question is correctly answered by thinking about a cuboid of air that is 36 m long and has a cross-sectional area equal to that of the shaded side of the tent. That cuboid corresponds to the air that hits the tent in the three second period. The force applied will be equal to the rate of momentum change. This means multiplying the mass of air that hits the tent by the velocity change (i.e. 12 m/s) and then dividing by the time taken for that momentum change.
	b		***Level 3 (5–6 marks)** Clear descriptions **and** explanations, supported by quantitative analysis *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description and some explanation or quantitative analysis **or** Clear explanation **or** Clear description **or** Clear quantitative analysis *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description **or** Limited explanation *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	B1×6	**Indicative scientific points may include**: **Description** • Increasing the area/diameter of the guy ropes • A different material with a larger breaking or yield stress • A more streamlined shape that allows the wind to pass over or around the tent **Explanation** • Correct reference/use of $F = \Delta p / \Delta t$ • Greater cross-sectional area of rope would reduce the stress • The rope would not exceed a higher breaking/yield stress • Changing shape produces a smaller momentum change and a smaller force • If the air passes over/around the tent, it still has some forward momentum and hence the change and force is less • Reduction of angle of ropes from ground reduces component of tension perpendicular to ground so tension decreases. **Quantitative analysis**

			0 marks *No response or no response worthy of credit.*		• Mass (per unit time) and velocity **both** double (at 40 m/s) • Momentum change is ×4 • Force would increase by a factor of 4 • Rope cross section must be × 4 (or diameter × 2) • Breaking or yield stress of material would need to be × 4 • Use of trigonometry to determine the angle of deflection that would reduce the momentum change by a factor of 4 (about 15° compared to the original 90°) **<u>Examiner's Comments</u>** This question tested ideas about forces, resolution of forces, behaviour of materials under stress and rate of change of momentum transfer. Level 1 answers were restricted to merely suggestions of what could be done to make the support of the tent stronger. Level 2 answers developed at least one of those suggestions by referring, qualitatively, to the underlying physics. Level 3 answers were rare, as the requirement was for some quantitative physics. Candidates that attempted a quantitative answer often believed that the force would be doubled, when in fact it is quadrupled. This is because both the mass of the air depends on the velocity of air, so doubling the speed will also double the mass, thus quadrupling the momentum transfer.

					 This candidate clearly states, on lines 3–5, that the force is directly proportional to the square of the speed by thinking about their answers to previous parts of the question. The statements following this, after the page break, are sensible and grounded in physics in topics typically covered in the first year of study. The candidate mentions about quadrupling the number of ropes and reducing the area presented to the wind by a factor of four. The candidate goes on, in the additional answer space, to refer to the thickness of the ropes and how the radius would need to double. Level 3 response.
			Total	**11**	
10			**B**	1	
			Total	**1**	
11			D	1	**Examiner's Comments** Candidates performed less well on this question. By equating moments, candidates could determine that $x \propto 1/F$. The most common distractor was answer C where candidates incorrectly equated the weight of W to the moment of force F.
			Total	**1**	
12	a	i	E_p(= 0.16 × 9.81 × 2.5)= 3.9 (J)	A1	3.924 **Examiner's Comments**

					This question was generally answered well.
		ii	$v^2 = \frac{2\times3.9}{0.16}$ or 48.75 OR $v^2 = 2 \times 9.81 \times 2.5$ or 49.05 $v = 7.0\ (\text{ms}^{-1})$	C1 A1	**Allow ECF** from (a)(i) **Allow** 1sf **<u>Examiner's Comments</u>** Most candidates correctly equated the change in gravitational potential energy to kinetic energy and gained the correct answer. Other candidates correctly used $v^2 = 2gh$. A number of candidates gave the answer as 7 (ms^{-1}) – since the data in the question was given to two significant figures the answers should also be given to two significant figures. Ideally the substitution of data into appropriate equations should be shown.
	b	i	$R(=12 \times 0.71) = 8.5(2)$ (m)	A1	**<u>Examiner's Comments</u>** It was expected that candidates would multiply the horizontal velocity by the time. This was generally answered well. **Assessment for learning** When considering projectile motion, candidates should treat the vertical and horizontal velocities independently.
		ii	$E_k = \frac{1}{2} \times 0.16 \times 12^2$ or 11.5 OR $= \frac{1}{2} \times 0.16 \times 13.9^2$ or $\frac{1}{2} \times 0.16 \times 193$ E_k (= 11.5 + (a)(i) = 11.5 + 3.9) = 15(.4) (J)	C1 A1	**Allow** use of vertical $v = 6.97$ (calculated using $v = u+at$;) **Allow** 15.5 (J) **Allow ECF** from (a)(i) **<u>Examiner's Comments</u>** Many candidates calculated the kinetic energy of the ball using the velocity of the ball in the horizontal direction but then did not add the

					change in potential energy of the ball as it fell. Other candidates determined the resultant velocity of the ball and then calculated the kinetic energy.
		iii	$\theta\left(=\tan^{-1}\left(\frac{(a)(ii)}{12}\right)=\tan^{-1}\left(\frac{7}{12}\right)\right)=30°$	A1	**Allow** ECF from (a)(ii) 30.256 **<u>Examiner's Comments</u>** Candidates achieving on this question correctly determined the angle using the horizontal and vertical velocities. Where the response was incorrect, candidates had used either energies or distances.
			Total	**7**	
13	a	i	Weight of *M* = 3.9 − (2.1 + 0.49) or 1.31 $M = \frac{1.31}{9.81}$ = 0.134 (kg) 0.13 (kg)	M1 M1 A0	**Allow** any rearrangement **<u>Examiner's Comments</u>** Most successful candidates stated the equilibrium of forces in the vertical direction. Some candidates incorrectly used a value of 10 N kg^{-1} rather than the value of 9.81 N kg^{-1} given on the data sheet.
		ii	1.3 × 0.1 OR 2.1 × 0.3 OR 0.49 × 0.38 1.3 × 0.1+2.1 × 0.3 + 0.49 × 0.38 = 0.9462 *d* = 0.24 (m)	C1 C1 A1	**Allow ECF** from (b)(i) **Allow** 1.28 or 1.31 for 1.3 **Allow** 1.28 or 1.31 for 1.3; 0.9442 or 0.9472 for 0.9462 **<u>Examiner's Comments</u>** Candidates who scored highly on this question clearly determined the individual moments. Common errors were ignoring moment due to the weight of the beam and incorrectly determining the distance for 0.49 N weight.
	b		Sum of the forces / net / resultant force (in any direction) = 0 Sum of the moments / net / resultant moment (about any point) = 0 Sum of the forces <u>in any direction</u> = 0	M1 M1	**Allow** (total) upward force = (total) downwards force **Allow** (total) clockwise moment = (total) anticlockwise moment **Allow** torque for moment

			and Sum of the moments /torques about any point = 0	A1	**Examiner's Comments** Candidates were often able to score marks for stating that the resultant force was zero (often referring to one direction, e.g., upwards) and that the resultant moment was zero. Very few candidates added the extra detail that the resultant force was zero **in any direction** and that the resultant moment **about any point** was zero. Candidates who were less successful were often vague in their use of terminology. For example, all the forces are the same without any reference to direction.
			Total	**8**	