6 Forces in equilibrium
Answers to practice questions

Question	Answer	Marks	Guidance
1 (a) (i)	1.30, 2.75, 4.35, 5.75, 7.15, 8.70	1	In part **(a)**, two sets of measurements are given of the newton meter reading for the load at different distances from the end of the beam on the pillar.
1 (a) (ii)	axes labelled correctly correct units shown on axes points plotted correctly best fit line drawn	1 1 1 1	The mean value of each distance measurement has to be calculated then used to plot a graph of the support force against this distance.
1 (b) (i)	Taking moments about X gives: $S\,D = W\,d + 0.5\,D\,W_o$, where W_o is the weight of the beam. Dividing each term by D gives the required equation.	2 1	Knowledge and understanding of the principle of moments and forces has to be used in part **(b)** to derive a theoretical equation in order to explain the graph and use it to find the weight of the load
1 (b) (ii)	Gradient = $\frac{W}{D}$ = 0.0184 N mm^{-1} therefore W = 480 mm × 0.0184 N mm^{-1} = 8.83 N	1 1 1	
1 (c) (i)	For the smallest readings, % error for d = $\frac{1}{40}$ × 100 = 2.5 %, % error for S = $\frac{0.1}{1.3}$ × 100 = 7.7 %	 1 1	Part **(c)** asks about the reliability of the measurements and the accuracy of the result.
1 (c) (ii)	Repeat the measurements for the same distances several more times to obtain a more reliable value for the mean support force at each distance.	1	
2 (a)	correct diagram drawn to a suitable scale magnitude of resultant = 13.6 (± 0.3) N required angle = 13 (± 2) °	1 1 1	You need to know how to find the resultant of two vectors by scale drawing when they act at **any** angle to each other.
2 (b)	$R^2 = 9.6^2 + 4.8^2$ gives R = 10.7 N	1 1	But you only need to know how to calculate the resultant when the vectors are **at 90 °** to each other.
3 (a) (i)	horizontal component = 850 × cos 42 ° = 630 N	1 1	You must know how to find the resolved components of vectors. If the required component is alongside the angle you are given, you need the cosine of the angle. If not, you need the sine.
3 (a) (ii)	vertical component = 850 × sin 42 ° = 570 N	 1	

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3 (a) (iii)	weight of girder = sum of vertical components of *T* = 2 × 570 = 1100 N (1140)	 1	The girder is stationary, so there is no resultant vertical force.
3 (b)	the weight acts vertically downwards at the centre of the girder	1	For a uniform girder, the centre of mass is mid-way along its length. The weight acts vertically downwards through this point.
4 (a)	the moment of a force about a point is the product of the force and the perpendicular distance from the point to the line of action of the force	1 1	You need to know this definition. 'Moment = force × distance' is how we usually apply the definition, but it is important to remember that the distance is the **perpendicular** distance. (Note also that 'work = force × distance', but in the case of work the distance has to be in the same direction as the force.)
4 (b) (i)	application of definition gives 46 = *F* × 0.25 cos 40 ° ∴ *F* = 240 N	1 1	The perpendicular distance from O to the line of action of *F* is the horizontal component of 0.25 m, which is 0.25 cos 40 °.
4 (b) (ii)	the moment of F increases to a maximum (when the crank is horizontal) and then decreases because the perpendicular distance increases and then decreases	1 1	You are asked to state and explain, so your answer must do both. As the crank rotates, the perpendicular distance from O to the line of action of *F* increases over the first 40 ° and then decreases over the next 40 °. The vertical force exerts no moment when the crank is in the vertical position (directly above or below O).
5 (a)	Forces on plank: two arrows vertically downwards to represent weight of student and load one arrow vertically downwards in centre of plank to represent weight of plank one arrow vertically upwards from the log to represent the upward force (reaction) at the pivot	1 1 1	The first marking point should be clear and obvious. The weight of the plank acts at its centre of mass, exactly half way along it because it has uniform cross-section. Don't overlook the upwards reaction at the pivot.
5 (b)	Taking moments about the pivot: clockwise moment = (25 × 9.81 × 1.0) + (*L* × 2.5) where *L* = load in N equated with anticlockwise moment = (65 × 9.81 × 0.50) gives load *L* = 29 N	1 1 1	Two of the forces produce a clockwise moment about the pivot, balanced by the moment due to the weight of the student on the opposite side. The upwards reaction at the pivot takes no part because it acts **through** the pivot, producing no moment. Note that you are asked for the load **in N** rather than for its mass in kg, so you do not have to divide the final answer by g.

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5 (c)	as the student walks towards the log, the anticlockwise moment decreases the clockwise moment is now greater than the anticlockwise, so the plank rotates clockwise until the load touches the ground	1 1	Rotation is caused by the moment of a force, not by force alone. Your explanation should refer to the effect of the student's movement on the moments acting about the pivot. The student does not have 'less weight' as he moves towards the pivot!