#1

1. (a) State in words the equation used to calculate the moment of a force about a point. [1]

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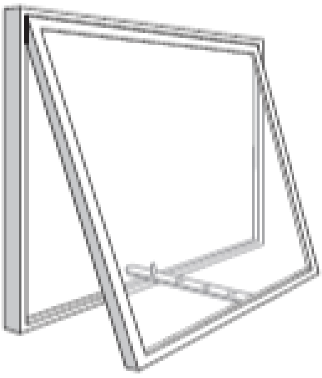
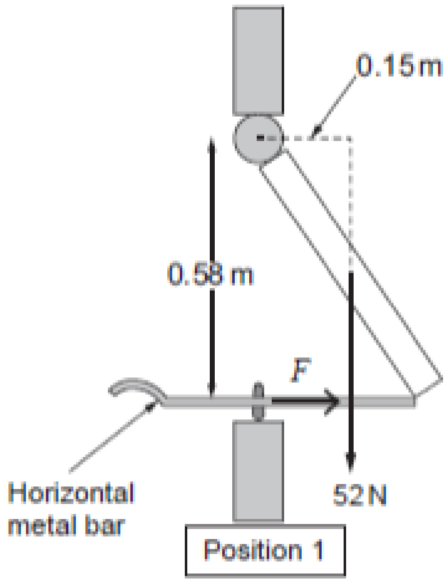
(b) The picture and diagram show a window hinged at the upper surface. The window is opened by pushing on the horizontal metal bar attached to its lower surface. Holes are drilled into the metal bar so that the window can be supported at various opening positions, one of which is shown below and labelled as Position 1. The hinge provides no resistance to the movement of the window.





(i) Show that the clockwise moment produced by the weight of the window is approximately 8 N m. [1]

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(ii) Hence calculate the force, F, the metal bar exerts on the window. [2]

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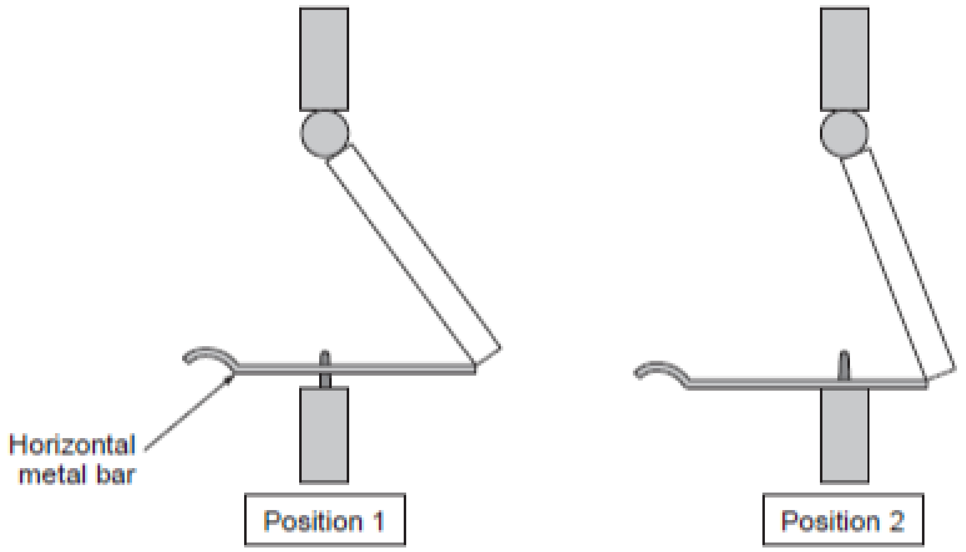
(c) Tom and Bethan discuss how the force in the metal bar changes with changing positions. Tom thinks that the force in the bar is greater when the window is in Position 2, whereas Bethan believes that the force is greater when the window is in Position 1. Discuss who is correct, giving a detailed explanation in terms of moments. Assume the metal bar is horizontal in both positions. [4]



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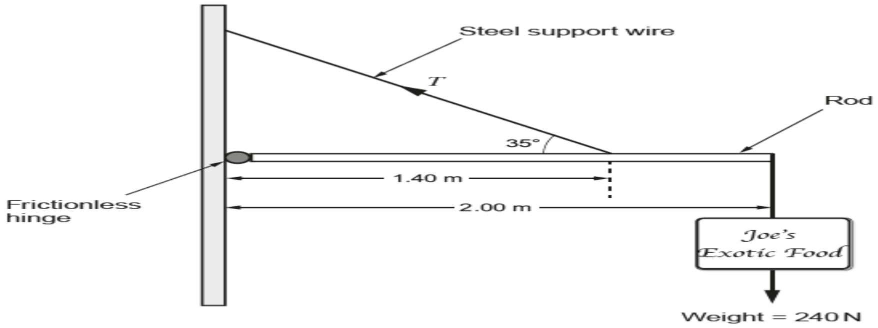
Question taken from WJEC examination paper 242501, June 2018

#2

(a) State the conditions necessary for a body to remain in equilibrium. [2]

(b) A shopkeeper wishes to hang a heavy sign of weight 240 N outside his shop using the following arrangement. He has steel wires of various diameters to choose from. You may neglect the weight of the rod.



The shopkeeper needs to ensure that the steel wire he decides to use has a breaking strength greater than is required to support the sign. By taking moments about an appropriate point, show that the tension, T, in the wire in the above diagram is approximately 600 N. [3]

(c) The shopkeeper finds the following information on a website advertising steel wire ropes.

Minimum breaking strength and safe working load of uncoated steel wire ropes are indicated below.

Diameter of rope / mm	Minimum breaking strength / N	Safe working load / N at 5:1 ratio	Safe working load / N at 3:1 ratio
1.5	1 900	380	633
2.0	2 750	550	916
2.5	3 300	660	1 100
3.0	5 400	1 080	1 800

Loading Information

SAFE WORKING LOAD (SWL) is the load that can be applied without causing any damage to the wire rope.

WE PROVIDE TWO SWLs FOR YOUR CONSIDERATION AT RATIOS 5:1 AND 3:1.

Factors of safety should always be applied when determining maximum wire rope loading conditions. If in doubt a suitably qualified engineer should be consulted to assess loading factors.

(i) Based on the information on the web page the shopkeeper decides to apply a SWL ratio of 3:1 for the wire he will use. State, giving your reasoning, which **minimum** diameter of wire rope he should choose to use. [2]

(ii) The shopkeeper has no engineering background. Evaluate whether or not he has made an informed decision. [2]

Question taken from WJEC examination paper 242501, June 2017

#3

5. Sam carries out an experiment to determine the mass of a metal block using the principle of moments.

(a) State the principle of moments. [2]

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(b) The metal block is in the form of a cuboid as shown in **Diagram 1**. When setting up the experiment Sam accidentally knocks the metal block so that it tilts to the position shown in **Diagram 2**. The block then returns to the upright position as in **Diagram 1**.

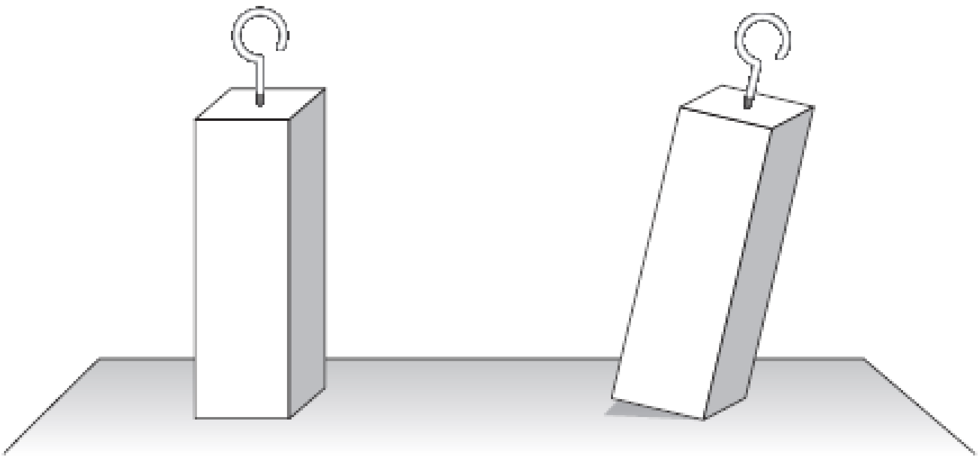

Diagram 1 **Diagram 2**

Explain, in terms of centre of gravity, why the block returns to the upright position. [2]

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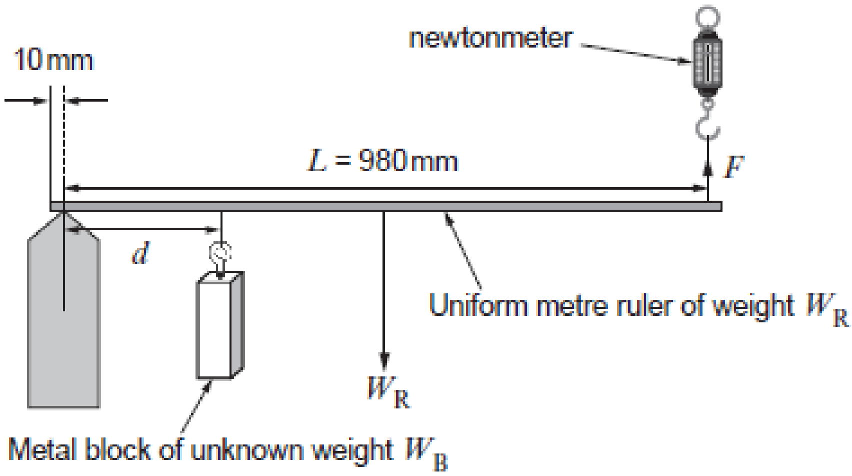
(c) Sam sets up the experiment as shown using a metre ruler.



Sam uses the newtonmeter to measure the force, F, needed to make the metre ruler horizontal for varying values of d. He carries out the experiment twice and determines a mean value for F for each of the distances d. Sam judges that the ruler is horizontal by eye before taking readings for F. The measurements are recorded in the table below.

Distance, d / mm	Force, F / N		
	Trial 1	Trial 2	Mean
100	2.8	2.6	
250	5.2	5.7	
400	8.8	8.5	
550	11.2	11.6	
700	14.6	14.5	
850	17.2	17.6	

(i) Complete the table. [1]

(ii) The following relationship is used to find the weight, W_B, of the block:

$$F = \frac{W_B d}{L} + \frac{W_R}{2}$$

By taking moments about the pivot, show how this relationship is obtained. [2]

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(iii) Use the grid to plot a graph of mean F (vertical axis) against d (in mm, on the horizontal axis) and draw a line of best fit. **Error bars should not be included.**

[4]

(iv) Use your graph to determine:

I. W_B, the weight of the metal block; [2]

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II. W_R, the weight of the ruler. [2]

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(d) The distances, d, were measured to a resolution of ±1 mm. Use data from the table of results to show that the percentage uncertainty in mean F is greater than the percentage uncertainty in d, when d = **100 mm**. [3]

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(e) Suggest **one** change to his method which would improve the quality of Sam's measurements. [1]

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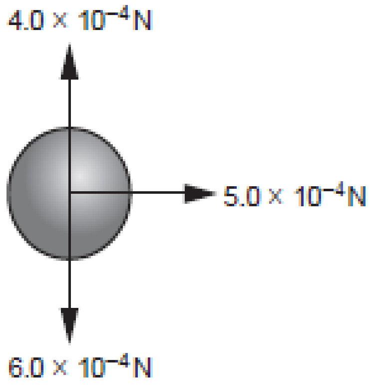
#4

2. (a) The forces acting on a hailstone falling in a horizontal cross-wind can be represented as in the diagram.



(i) Calculate the magnitude and direction of the resultant force acting on the hailstone. [3]

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(ii) At a later time, the wind has stopped blowing and the hailstone falls at terminal velocity. In terms of forces, explain why the hailstone is at terminal velocity. [1]

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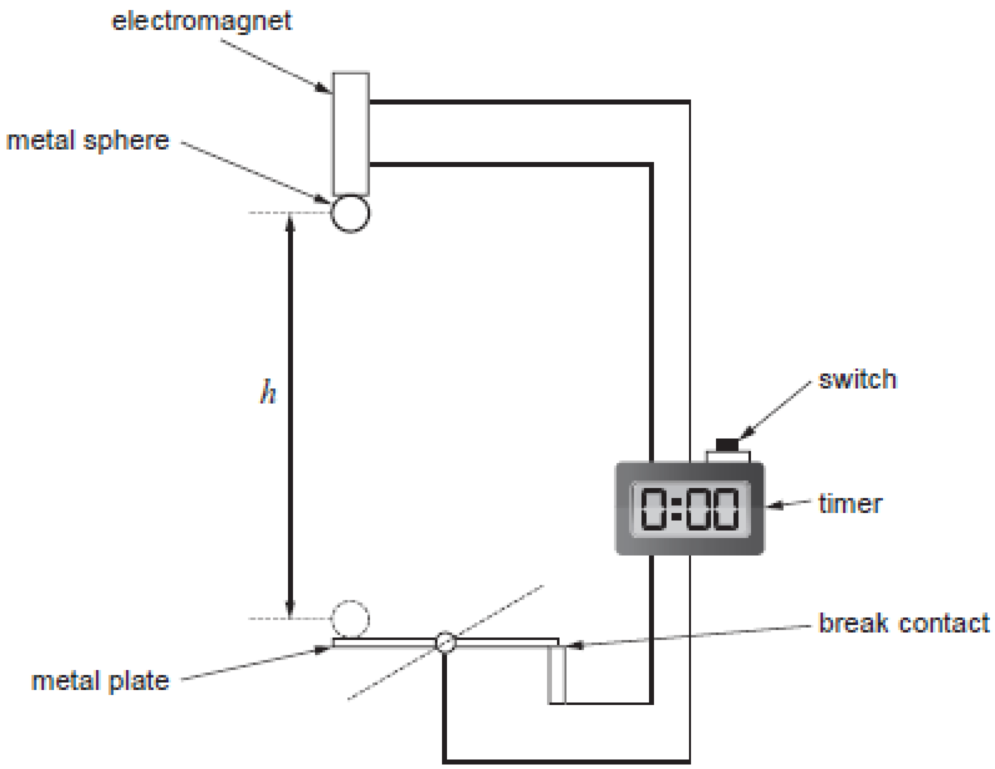
(b) Aled uses the following apparatus to measure the acceleration of free-fall, g.



When the switch is pressed, it starts the timer and disconnects the electromagnet, almost instantly releasing the metal sphere. When the sphere hits the metal plate it breaks the circuit, stopping the timer. The time taken for the metal sphere to fall through a range of different heights, h is measured.

(i) Aled is told that there is a very small time delay between the switch being pressed and the ball being released. This is a systematic error. The manufacturer states that the time delay is 0.05 s. State how Aled should account for the systematic error when taking readings. [1]

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(ii) Aled records his **corrected results (i.e. with the systematic error accounted for)** in the table below. Complete the row for time squared, t^2 giving your answers to an appropriate number of significant figures. [2]

Drop height, h/m	0.40	0.80	1.20	1.60	2.00
Corrected time, t/s	0.27	0.41	0.48	0.58	0.64
Corrected time squared, t^2/s^2					

(iii) The following relationship is used to find a value for g:

$$g = \frac{2h}{t^2}$$

Show how this relationship is obtained from an appropriate equation of accelerated motion. [2]

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(iv) On the grid below, plot a graph of h (vertical axis) against t^2 (horizontal axis) and draw a line of best fit. [4]

(v) Use your graph to determine a value for g. [3]

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(c) Discuss to what extent your graph agrees with the equation in *(b)*(iii). [3]

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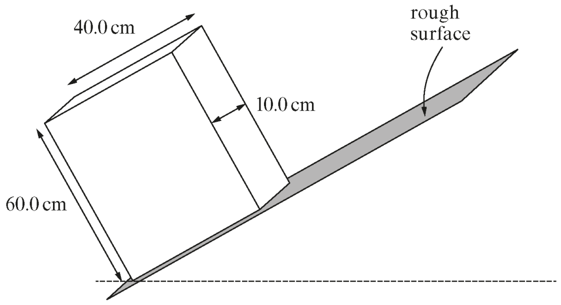
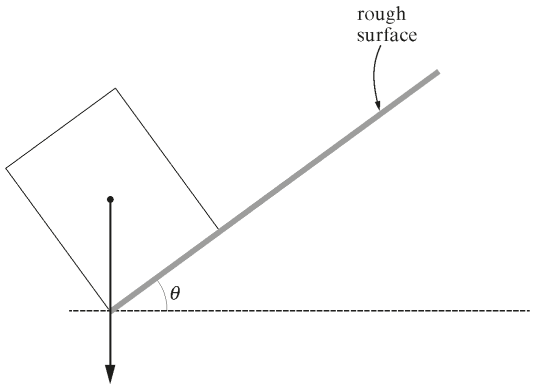
Question taken from WJEC examination paper 242501, June 2018

#5

(a) A solid block of uniform density with sides 60.0 cm, 40.0 cm and 10.0 cm rests on a sloping rough surface.



The following diagram shows the block viewed from the side **at the point of toppling**. An arrow is shown passing through the centre of gravity of the block.



(i) Explain what is meant by 'centre of gravity'. [1]

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(ii) Calculate the angle θ. Assume that no sliding occurs. [2]

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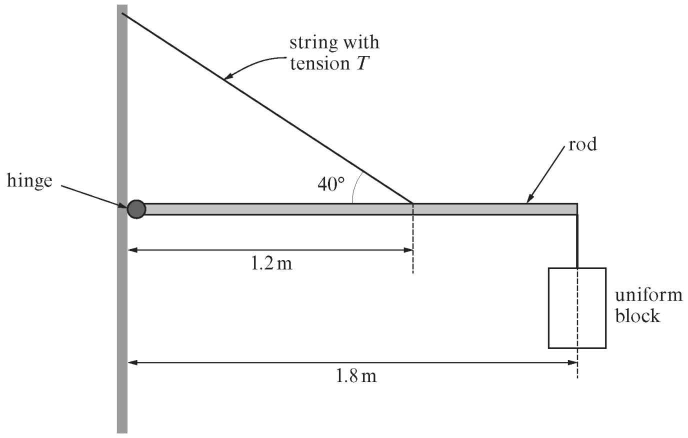
(b) The block (in part *(a)*) is now attached to a rod of **negligible weight** which is supported by a string and a frictionless hinge as shown in the diagram below.



(i) The density of the material of the block is $400\,\text{kg}\,\text{m}^{-3}$. Show that the mass of the block is 9.6 kg. [2]

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(ii) By taking moments about the hinge, calculate the tension in the string. [4]

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(iii) Hence calculate the horizontal component of the force that the rod exerts on the hinge. [2]

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Question taken from WJEC examination paper 132101, January 2013

#6

(a) Explain, with the aid of a diagram, what is meant by the moment of a force about a point. [2]

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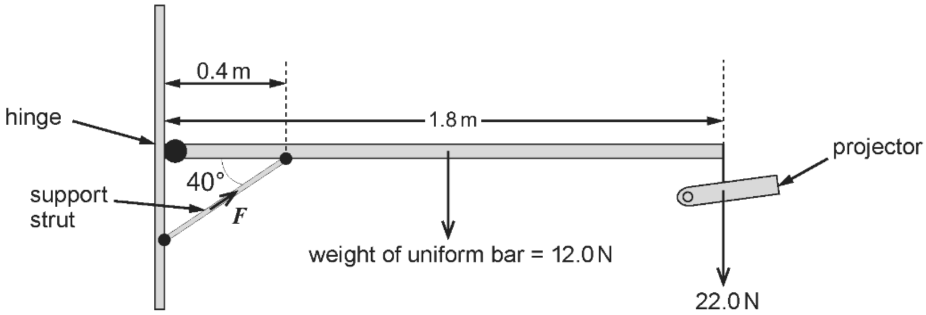
(b) A classroom projector is set up as shown.



(i) By taking moments about the hinge, show that the force, ***F***, exerted by the support strut on the uniform bar is approximately 200 N. [3]

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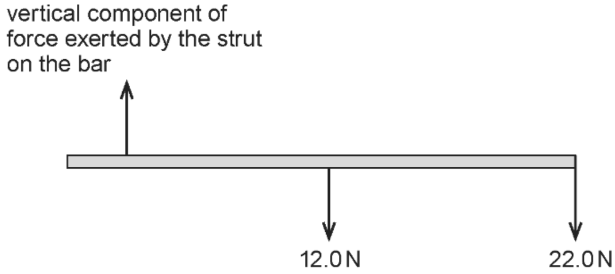
(ii) The free body diagram below shows **some of the vertical forces** acting on the uniform bar.



(I) Calculate the value of the **vertical component** of the force exerted by the strut on the bar. [1]

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(II) Indicate, with an arrow **on the diagram**, the direction of the vertical force on the bar due to the hinge. [1]

(III) Calculate the size of the vertical force on the bar due to the hinge. [1]

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Question taken from WJEC examination paper 132101, May 2015

#7

7. *(a)* One condition for a body to remain in equilibrium is that there should be *no net moment* acting on it about any point. State the other condition necessary for a body to remain in equilibrium. [1]

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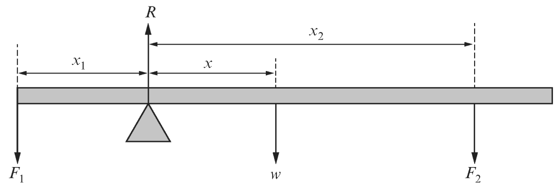
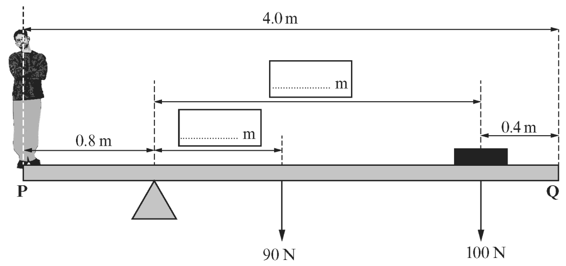
(b) The diagram shows a uniform plank of weight w pivoted so that it remains in equilibrium when forces F_1 and F_2 are applied to it at distances x_1 and x_2 as shown. R represents the contact force at the pivot.



Applying the principle of moments about the pivot, complete the equation: [1]

$F_1 x_1 =$ ....

(c) An experiment is carried out to find the weight of a Physics student. A uniform plank of wood **PQ**, 4.0 m long and weighing 90 N is pivoted about a point 0.8 m from **P**. A 100 N weight is placed 0.4 m from **Q** in order to balance the plank horizontally.



(i) Use the information given to fill in the two blank boxes with relevant distances. [1]

(ii) Hence calculate the weight of the student. [2]

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(iii) Determine the value of the force exerted by the pivot on the plank. [1]

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(iv) By taking moments about **Q**, and using your answers to *(c)*(ii) and *(c)*(iii), confirm that the plank is in equilibrium. [2]

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(v) The student now steps off the plank and is replaced by another, heavier student who stands at point **P**. Which way must the **pivot** be moved in order to balance the plank horizontally? Explain your answer. [2]

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7. *(a)* A student gives the following **incorrect** and **incomplete** definition of the moment of a force about a point.

Moment of a force about a point = mass × distance

Correct the definition. [2]

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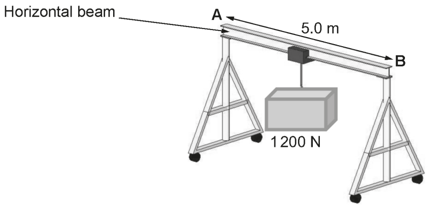
(b) A simple gantry crane is used to transport heavy loads. It consists of a horizontal beam (**AB**) of length 5.0 m fixed at each end to a vertical pillar as shown. It is possible to move the load along the horizontal beam.



When the gantry crane supports a load of 1200 N **at its centre**, a force of 700 N is exerted on each pillar. Calculate the weight of the horizontal beam. [2]

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(c) The same load is now **moved 1.0 m towards B**.

(i) Draw arrows on the diagram below to show the forces now acting on the beam. [2]

(ii) By taking moments about a suitable point, calculate the force on the beam at **B**. [3]

(iii) Hence calculate the force on the beam at **A**. [1]

Question taken from WJEC examination paper 132101, May 2014

#9 (a) A student gives the following incorrect and incomplete definition of the moment of a
force about a point.

Moment of a force about a point = mass × distance

Correct the definition.

[2]

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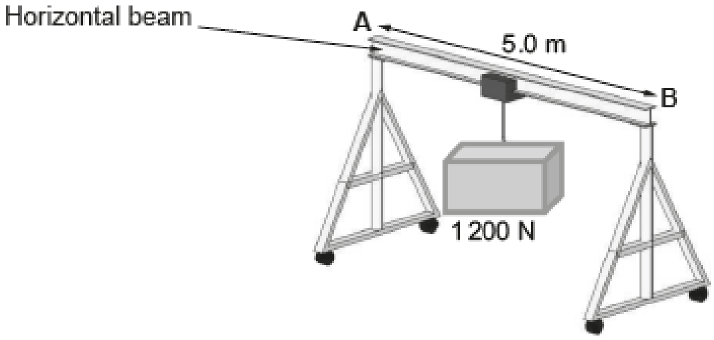
(b) A simple gantry crane is used to transport heavy loads. It consists of a horizontal beam
(AB) of length 5.0 m fixed at each end to a vertical pillar as shown. It is possible to move
the load along the horizontal beam.



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(c) The same load is now moved 1.0 m towards B.
(i) Draw arrows on the diagram below to show the forces now acting on the beam.

[2]

(ii) By taking moments about a suitable point, calculate the force on the beam at B.

[3]

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(iii) Hence calculate the force on the beam at A.

[1]

Question taken from WJEC examination paper 132101, August 2015

#10

(a) What name is given to the turning effect of a force? [1]

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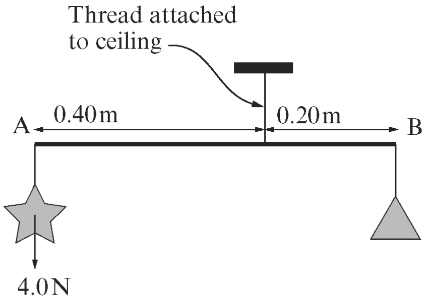
(b) (i) A simple toy mobile, consisting of a star and a triangle is shown hanging freely. Assume the rod AB is weightless. Calculate the weight of the triangle. [2]



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(ii) Hence calculate the tension in the thread attached to the ceiling. [1]

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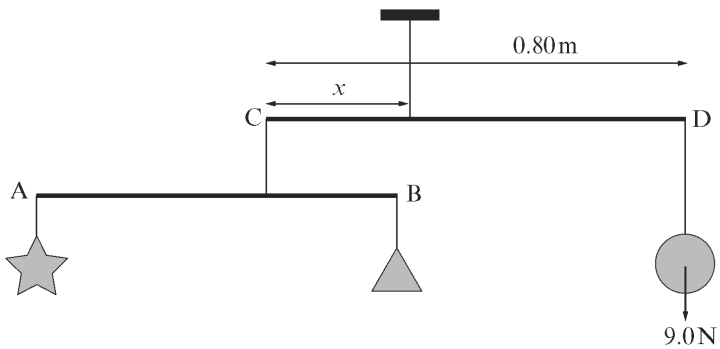
(c) The mobile is now attached to another weightless rod CD of length 0.80 m, making a more complex mobile as shown. A sphere of weight 9.0 N is attached to D and the mobile is hung freely from the ceiling.



(i) The distance x can be adjusted to allow the rod CD to hang horizontally. Calculate x. [3]

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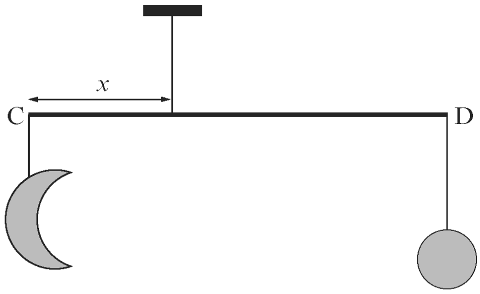
(ii) The original star and triangle mobile is now replaced with a single 'crescent moon' of weight 12.0 N as shown. Explain whether x will now have to increase, decrease or stay the same to keep CD horizontal. [2]



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Question taken from WJEC examination paper 132101, May 2011