CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 3 January 2023 series

Contents

Introduction

Our examiners’ reports are produced to offer constructive feedback on candidates’ performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates’ performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Unit 3 series overview

This Level 3 paper examined the Principles of mechanical engineering. It followed a similar format to previous papers.

To do well on this paper, candidates needed to:

- be familiar with all the parts of the specification examined
- show clear and legible workings especially for 2-, 3-, 4- and 5-mark questions
- attempt all questions
- be familiar with and make appropriate use of the formula booklet
- be familiar with and make use of engineering language and terms.

The paper appeared to be accessible with most questions being attempted by candidates from many centres. However, candidates from some centres demonstrated limited understanding of properties of beams and bending moment diagrams.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• used appropriate engineering language • showed clear working in calculations • attempted all questions • converted units correctly • showed familiarity with all parts of the specification including properties of beams.	• made careless mistakes in calculations • used incorrect engineering language • seemed to be less familiar with some parts of the specification including properties of beams • seemed unfamiliar with the contents of the Formula Booklet.

Question 1 (a) (i)

1 **Fig. 1** shows a bolt being subjected to particular loading conditions.

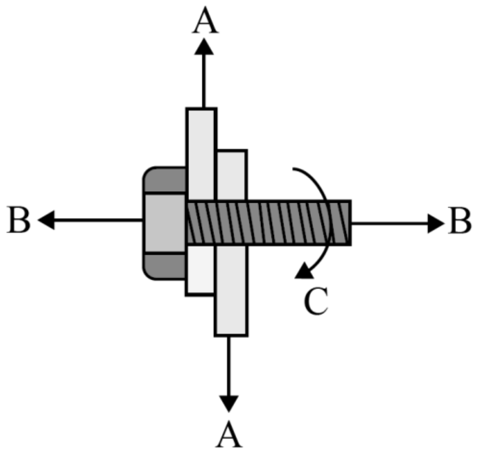


Fig. 1

(a) **(i)** State which of the arrows (A, B or C) represent the following type of loading on the bolt:

Torque ....

Shear force ....

Tension force .... **[2]**

Candidates were expected to identify the different types of loading. Most candidates scored 1 or 2 marks.

Question 1 (a) (ii)

(ii) The bolt is considered to be in single shear subjected to a shear force of 250 N.

The diameter of the bolt is 16 mm.

Calculate the shear stress in the bolt. Give the units for your answer.

....

....

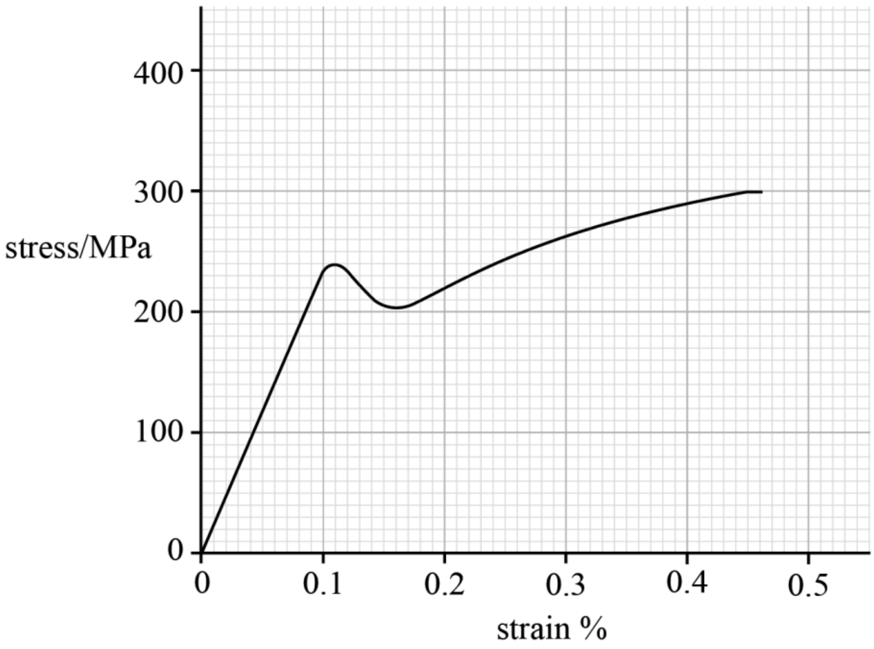
....

.... **[3]**

Candidates were expected to calculate the shear area and to use this to calculate density. Many candidates did this correctly and scored all 3 marks. Many candidates who did not score full marks were given up to 3 marks by using the equations for density and area of a circle and by substitution of values.

Question 1 (b) (i)

(b) This is a stress–strain graph for steel used to make wires.



(i) On the graph, mark an X to show the position of the elastic limit.

[1]

Candidates were expected to mark on the line the position of the elastic limit within the tolerance allowed. Most candidates did this successfully but some did not put the cross on the line and so were not given this mark.

Question 1 (b) (ii)

(ii) An engineer studying the graph attempts to calculate Young's modulus for this steel.

The engineer uses the following calculation:

$$\text{Young's modulus} = \frac{\text{stress}}{\text{strain}} = \frac{260 \times 10^6}{0.3} = 8.67 \times 10^8 \text{ Pa.}$$

Identify **two** errors made in the engineer's calculation.

1 ....

....

2 ....

.... **[2]**

Most candidates scored at least 1 mark and many scored 2. The first mark was available for stating that the point used in the calculation was not within the elastic region. Candidates who referred to a single specific value that "should" have been used did not score this mark.

The second mark was for stating that the stress value used was a % (and had not been converted to the decimal value). Stating that the calculation used % strain was the minimum acceptable response required to score the second mark.

Question 1 (b) (iii)

(iii) A wire made from this steel with an initial length of 1.2 m is subjected to a tensile force which causes a stress of 140 MPa.

Calculate the increase in length of the wire.

Give your answer in millimetres.

....

....

.... **[3]**

Candidates were expected to use the graph to find the strain value and to use this value in the defining equation for strain to calculate the change in length. Many candidates did this correctly, and gave their answer in mm, so scored all 3 marks. Candidates who did not score full marks could score 1 mark for showing evidence either on the graph or in their calculations that they had attempted to find the strain value. A second mark could be scored by multiplying their strain value by the original length.

Note that some candidates used an alternative method by using data from the graph to find the Young's modulus. This method scored full marks but only if the correct answer was written down. Note that this method can introduce additional errors (compared to using the defining equation for strain) and these candidates therefore scored either 3 or 0 marks.

Question 2 (a)

2 **(a)** Describe **one** advantage of using a gear system instead of a flat belt and pulley system.

.... **[1]**

Candidates were expected to recall types of gear system and types of pulley and belt drive systems. Specifically in this question they were expected to state an advantage of a gear system over a belt and pulley system. Most candidates gave an acceptable response with many referring to the possibility of slipping or breaking of belts.

Question 2 (b)

(b) State **two** different types of gear or gear system.

1 ....

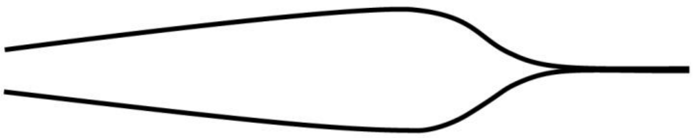
2 ....

[2]

Candidates were expected to recall two different types of gear systems and most candidates scored 1 or 2 marks.

Question 2 (c) (i)

(c) This is a diagram of a pair of tweezers which can be modelled as a lever.



(i) On the diagram label with arrows:

- the fulcrum
- the input force (F_I)
- the output force (F_O).

[2]

Candidates were expected to show the position of the fulcrum for 1 mark and to draw force arrows for both input force and output force for the second mark. Most candidates scored the first mark but fewer candidates scored the second. Candidates who did not score the second mark used lines instead of arrows or had arrows pointing in the wrong directions or reversed the input and output arrows. Strictly, pairs of forces should have been drawn but the second mark was given even if candidates showed two single arrows approximately at 90 degrees to the surface and in the correct positions.

Question 2 (c) (ii)

(ii) State the class of lever for these tweezers.

.... **[1]**

Candidates were expected to identify this as a type 3 lever and most did this correctly.

Question 2 (d)

(d) **Fig. 2** shows two gears, A and B, combined with two pulleys, C and D.

Gear A is the input gear and is meshed with gear B.

Pulley D is an output pulley and is driven by a flat belt connected to pulley C.

Pulley C rotates on the same shaft as gear B.

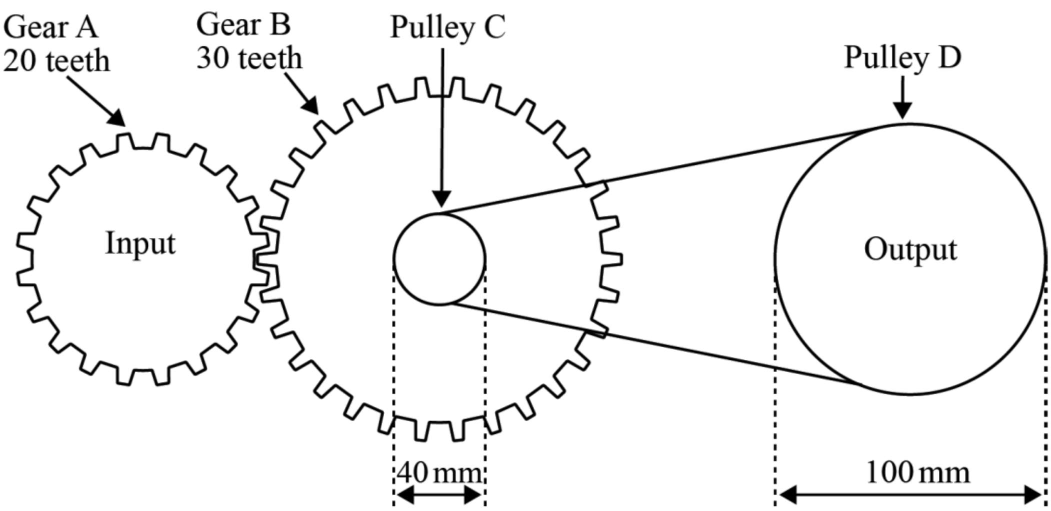


Fig. 2

The rotational speed of the input gear, A, is 75 rpm.

Calculate the rotational speed of the output pulley, D in rpm.

....

....

....

....

....

.... **[4]**

Candidates were expected to calculate the relevant velocity ratios (VR) and to use these together with the given rotational speed of the input gear to calculate the rotational speed of the output gear. Many candidates did this correctly and scored full marks, as did a small number of candidates who used mechanical advantage (MA) correctly. Some candidates who did not score full marks received credit for correct calculations of VR or MA and the rotational speed of the output gear. As a general rule, candidates should give their calculated answers to an appropriate number of significant figures. In this case a final answer given as a fraction was penalised and such candidates scored a maximum of 3 marks.

Assessment for learning

Centres should make sure that when questions require calculations, answers should be given to appropriate number of significant figures and rounded correctly. Centres should also make sure that candidates understand what is meant by "appropriate" in this respect.

Question 3 (i)

3 **Fig. 3** shows a plate, OABC, aligned within a Cartesian coordinate system, (x, y), with the origin at point O.

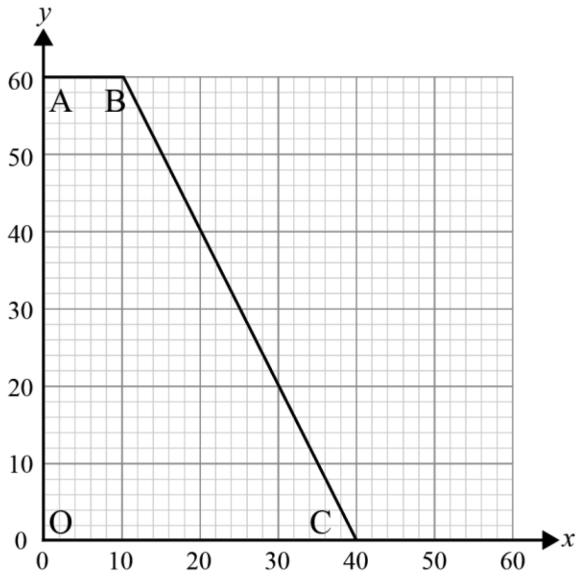


Fig. 3

(i) Calculate the x-coordinate and y-coordinate of the centroid of the plate.

....

....

....

....

....

.... **[5]**

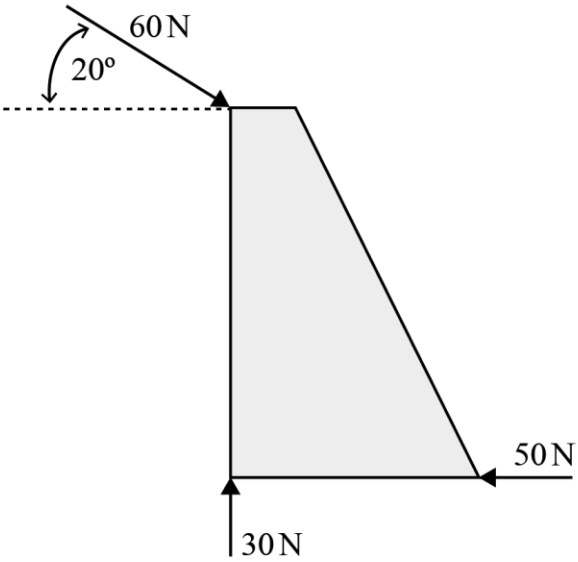
Candidates were expected to recall how to use the moment of area of uniform regular 2D shapes (in this case a triangle and a rectangle) to find the position of the centroid of a more complex uniform shape. Many candidates calculated the x-coordinate and the y-coordinate of the centroid correctly and so scored full marks. Many candidates who did not score full marks scored 1 or 2 marks by stating the coordinates of the centroids and the areas for one or both of the triangle and the rectangle. A third mark was scored by some by dividing their sum of a_ix_i (or a_iy_i) by their total area. Candidates who calculated one of the ordinates correctly could score a maximum of 4 marks. Questions similar to this have been seen in several previous papers and it seems that many centres have ensured that candidates were well prepared for questions of this type.

Assessment for learning

Mark schemes for previous papers are available and centres are reminded that these, together with the specification, provide a valuable resource in preparing candidates for examinations.

Question 3 (ii)

(ii) The plate is now subjected to the three co-planar forces of 60 N, 30 N and 50 N as shown below.



Explain, with a reason, whether these three forces are concurrent or non-concurrent.

....

.... **[1]**

Candidates were expected to state that this system of forces is non-concurrent and to explain correctly why this is the case. Many candidates scored 1 mark but most candidates made a correct statement without a correct justification and so scored 0.

Question 3 (iii)

(iii) Calculate the magnitude of the resultant of these three forces.

....

....

....

....

....

.... **[4]**

Candidates were expected to calculate the vertical and horizontal components of the resultant force and to add these two vectors together to find the resultant (using Pythagoras' theorem). Many candidates did this correctly and so scored full marks. Some candidates scored 1 mark for each correct component and a third mark for attempting to calculate the resultant of their calculated components.

Question 4 (i)

4 A car of mass 1800 kg travels along a horizontal road. At a particular time the car experiences a driving force of 3000 N and a total resistance force of 600 N.

(i) Calculate the acceleration of the car at this time.

....

....

....

.... **[3]**

Candidates were expected to apply Newton's Second Law in the horizontal direction to find the acceleration. Many candidates who did this correctly scored full marks. Candidates who did not score full marks could score 1 mark for calculating the resultant force correctly and a second mark for dividing their force by mass to calculate acceleration.

Question 4 (ii)

(ii) Calculate the instantaneous power of the car when it is travelling with a speed of $10\,\mathrm{m\,s^{-1}}$.

Give the units in your answer.

....

....

.... **[2]**

Many candidates gave the correct numerical answer with the correct unit (Watts) and so scored both marks. Many others scored 1 mark by calculating the correct numerical answer or by using the correct unit.

Question 4 (iii)

In a period when the car increases its speed from $10\,\mathrm{m\,s^{-1}}$ to $26\,\mathrm{m\,s^{-1}}$ assume that acceleration is constant and equal to $0.8\,\mathrm{m\,s^{-2}}$.

(iii) Calculate the distance travelled by the car in this period.

....

....

....

.... **[3]**

Candidates were expected to use the appropriate suvat equation to calculate displacement. Many candidates did this correctly and so scored full marks. Some candidates who did not score full marks scored 1 mark for selecting the appropriate suvat equation and a second mark for substituting the correct values into the correct equation (with or without rearrangement).

Question 4 (iv)

(iv) Calculate the increase in kinetic energy of the car in this period.

....

....

.... **[2]**

Candidates were expected to calculate the change in kinetic energy. Many candidates who did this correctly scored both marks. The candidates who did not score both marks scored 1 mark by calculating either the initial kinetic energy or the final kinetic energy.

Question 5 (a) (i)

5 **(a)** A box of mass 30 kg rests on a rough horizontal floor. A person attempts to push the box along the floor by applying a horizontal force of 75 N.

(i) Draw a diagram showing **all** forces acting on the box.

[2]

Candidates were expected to draw arrows to represent all forces acting and to label them appropriately. Many candidates showed four correct arrows with correct labels and scored both marks. Some candidates scored 1 mark by showing two correctly labelled arrows. Some candidates used lines without arrow heads and scored 0 marks.

Question 5 (a) (ii)

(ii) The coefficient of friction between the surface of the box and the floor is 0.27.

Determine whether the person attempting to push the box is successful in making it move.

....

....

.... **[2]**

Only candidates who calculated the value of the maximum friction correctly could score marks on this question. Many candidates calculated this correctly and stated that the attempt was not successful so scored 2 marks. A small number of candidates scored 1 mark by calculating the correct value but making an incorrect statement.

Question 5 (b) (i)

(b) A red snooker ball is a sphere with diameter 57.2 mm and mass 160 g.

(i) Calculate the density of the material the red ball is made from.

Give your answer in units of kilograms per cubic metre.

....

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....

.... **[4]**

Candidates were expected to recall and use the defining equation for density and the correct expression for the volume of a sphere to find the density in the required units. Many candidates did this successfully and scored full marks. Many others who did not score full marks scored 1 mark for using the defining equation for density, a second mark for using the correct expression for the volume of a sphere and a third mark for substituting values correctly into both expressions. Some candidates scored 3 marks rather than 4 because their answers were not converted to the required units.

Question 5 (b) (ii)

(ii) A white ball with diameter 57.2 mm and mass 170 g moving at a speed of 0.9 m s^{-1} directly hits a stationary red ball. Immediately after the collision the white ball continues to move in the same direction as before with a speed of 0.027 m s^{-1}.

Assuming that total momentum is conserved, calculate the speed of the red ball immediately after the collision.

....

....

.... **[3]**

Candidates were expected to use the principle of conservation of momentum to calculate the unknown velocity. Many candidates who did this correctly scored full marks. Candidates who did not score full marks could score 1 mark for calculating the momentum of the white ball before or after the collision. Candidates could score 2 marks by writing down correctly the full statement of conservation of momentum.

Assessment for learning

Centres should remind candidates about the importance of showing their workings clearly, legibly and in a structured way. This will allow them to score marks even when their answer is incorrect.

Question 6 (a)

6 (a) **Fig. 4** shows a cantilever beam subjected to three point loads of 8 kN, 10 kN, and 15 kN. The beam has a self-weight of 300 N m^{-1}.

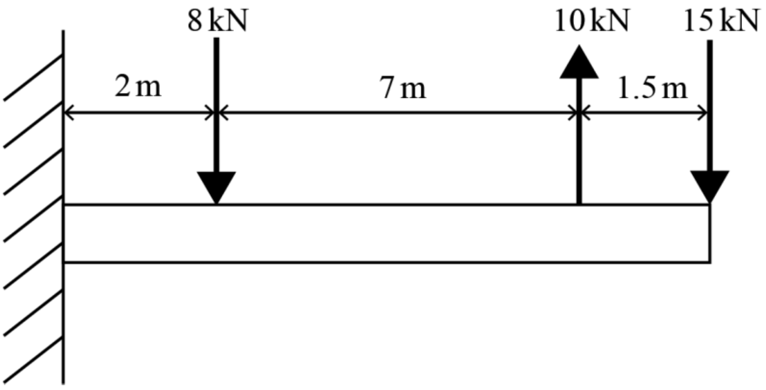

Fig. 4

Calculate the magnitude of the reaction force at the wall.

....

....

....

.... **[3]**

Candidates were expected to resolve forces in the vertical direction to find the reaction force. Candidates who did this correctly scored all 3 marks. The alternative method taking moments about an appropriate point could also score full marks but while many candidates attempted this, very few were successful.

Many candidates omitted (or did not calculate correctly) the self-weight of the beam. Candidates who did not score full marks could score 1 mark by calculating the self-weight correctly or by writing down a correct statement of vertical equilibrium ignoring self-weight.

Question 6 (b) (i)

(b) **Fig. 5** shows a beam with two point loads, and two reaction forces R_A and R_B. The point loads have magnitude 2000 N and P N. The magnitude of reaction force R_B is 3800 N.

The bending moment diagram for the beam has been drawn for you, with some key values provided. The self-weight of the beam can be ignored.

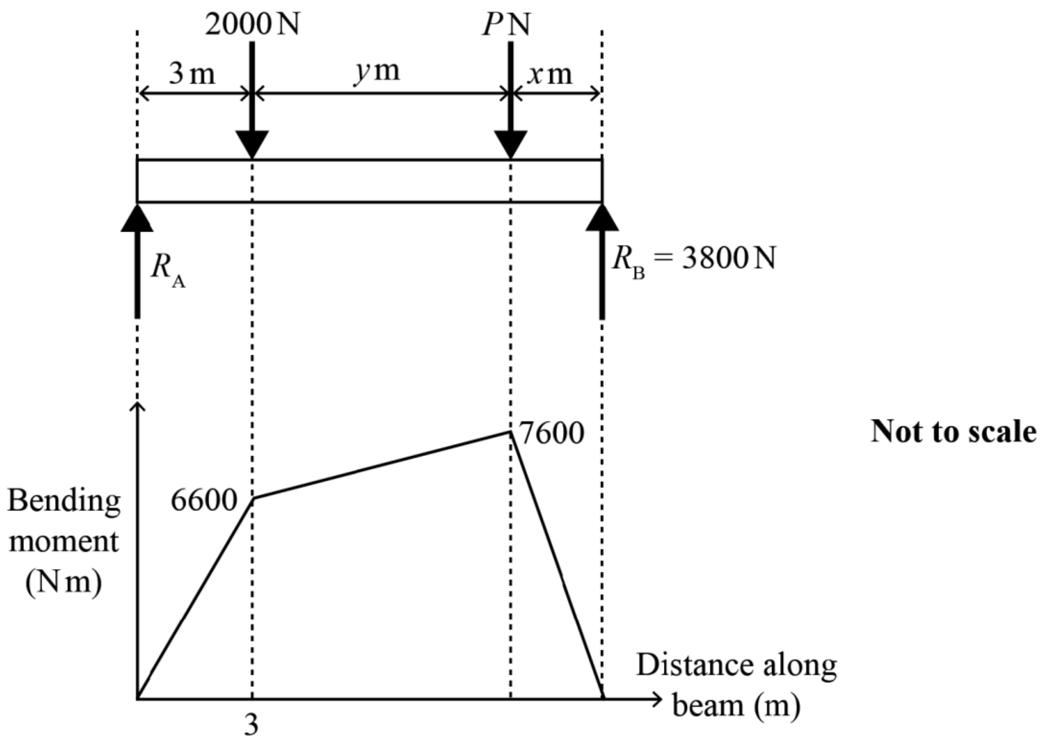

Fig. 5

(i) Calculate the magnitude of reaction force R_A and the distance x.

....

....

....

.... **[2]**

Candidates were expected to use the bending moment diagram to calculate the values of R_A and x.

Some candidates did this successfully and so scored both marks. Many candidates seemed unsure about this area of the specification and scored 0. Some candidates scored 1 mark for calculating R_A or x correctly.

If neither answer was correct, candidates could score 1 mark by writing down an appropriate correct statement from the bending moment diagram.

Assessment for learning

Centres should make sure that candidates understand how to calculate the bending moment at any point in a simply supported beam or, as in this case, to use information from the bending moment diagram to find unknown forces or distance.

Question 6 (b) (ii)

(ii) Calculate the magnitude of point load P and the distance y.

....

....

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....

....

.... **[3]**

Candidates were expected to resolve forces vertically to calculate P (using the correct value of R_A from the bending moment diagram) and to take moments about an appropriate point to find the value of x. Some candidates did this correctly and so scored 3 marks. Many candidates scored 0.

Candidates who calculated one of the values correctly could score 2 marks by writing down a correct statement of vertical equilibrium or moments.

Candidates who did not calculate either value correctly could score 1 mark by writing down a correct statement of vertical equilibrium or moments.

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