CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 3 January 2025 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 Teach Cambridge.

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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
- be familiar with, and make use of, engineering language and terms
- attempt all questions
- be familiar with, and make appropriate use of, the contents of the formula booklet provided
- show clear and legible workings especially for 3, 4, 5 and 6 mark questions.

The paper was accessible with most questions being attempted by candidates from many centres.

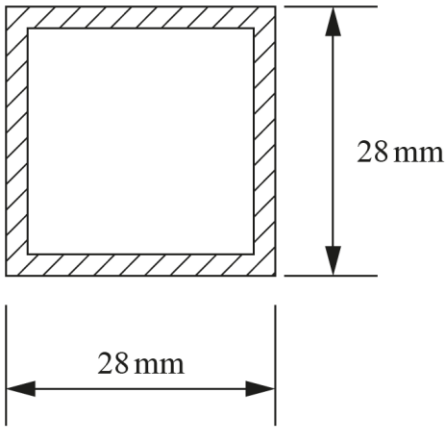
However, many candidates demonstrated limited knowledge of how to calculate bending moments for a cantilevered beam and then use these to draw a bending moment diagram. Most candidates also demonstrated uncertainty in how to use the conservation of energy principle.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• converted prefixes correctly • gave answers to a consistent number of significant figures • used engineering terms correctly • set out their calculations clearly • included correct units in their answers • made good use of the formula booklet.	• missed out parts of individual questions • did not attempt all the questions • did not show any working out in calculations.

Question 1 (a) (i)

1

(a) The square cross-section of a mild steel tube is shown below.



The thickness of the walls of the tube is 2 mm.

(i) Calculate the cross-sectional area of the mild steel in the tube.

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..... **[2]**

Many candidates did not take 2mm from both sides of the outer square so ended up with the inner area being 26mm x 26mm rather than 24mm x 24mm which was an incorrect answer.

Assessment for learning

Moving forward, centres should make sure candidates are well prepared for this common error through practice.

Question 1 (a) (ii)

(ii) The length of the tube is 750 mm. The density of mild steel used is 7870 kg m^{-3}.

Calculate the mass of the tube.

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..... **[3]**

Most candidates were able to convert the area to the volume and then multiply by the density to gain the mass. However, many candidates did not convert the volume from mm^3 to m^3 correctly so did not achieve full marks.

Key point. Conversion of units

Candidates need to be aware that if they are converting an area from mm^2 to m^2 or a volume from mm^3 to m^3 they need to divide by 1000^2 or 1000^3, not just 1000.

Question 1 (b) (i)

(b) A solid mild steel bar of length 100 mm with a cross-sectional area of 175 mm^2 is subjected to an axial load of 1250 N.

(i) Calculate the stress in the bar.

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..... **[1]**

Most candidates answered this question well.

Question 1 (b) (ii)

(ii) Young's modulus for the mild steel used is 210 GPa. The initial length of the bar is 100 mm.

Calculate the change in length of the bar caused by the load.

..... [3]

Many candidates did not get full marks here due to getting the answer to the incorrect power of 10. This was due to the incorrect conversion of Nmm^{-2} to Nm^{-2}, incorrect use of the prefix G or not converting the original length from mm into m without showing their units.

Key point. Answers requiring more than one calculation

In answers where more than one calculation is required, it is good practice to show these separately rather than just writing all the numbers down in one line. The exemplar shows a good case of how this can be done.

Exemplar 1

$YM = \frac{\text{Stress}}{\text{Strain}}$ $\quad 210 \times 10^9 = \frac{7.14 \times 10^6}{\text{Strain}}$ $\rightarrow \frac{7.14 \times 10^6}{210 \times 10^9} = 3.4 \times 10^{-5}$

$\text{Strain} = \frac{\text{change in length}}{\text{original length}}$ $\quad 3.4 \times 10^{-5} = \frac{\text{change in length}}{100}$

change in length $= 3.4 \times 10^{-5} \times 100$

$= 3.4 \times 10^{-3}$ mm

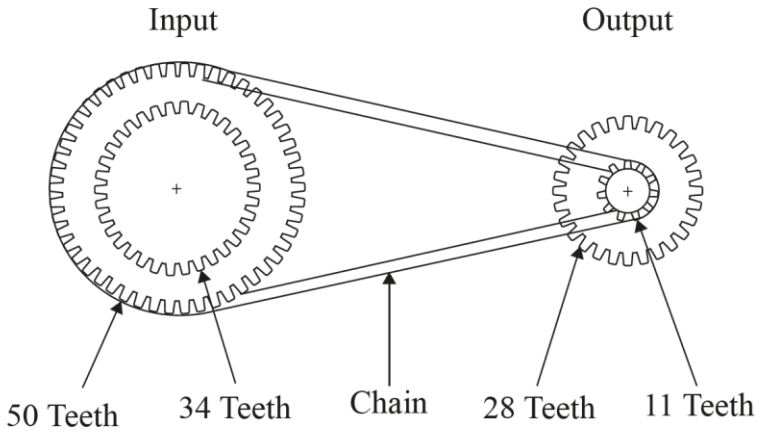
..... [3]

This is a good case of how the calculations are shown clearly at each stage and that the final answer has been quoted with correct units.

Question 2 (a) (i)

2

(a) A chained gear system is shown below. The chain is in the position required to provide the highest velocity ratio for the system.



(i) Calculate the velocity ratio of the system shown.

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..... **[2]**

While most candidates realised that the velocity ratio is given by input teeth/output teeth, many added or multiplied the two inputs and two outputs to then get an incorrect value.

Question 2 (a) (ii)

The chain is now repositioned so that the system provides the lowest velocity ratio. In this arrangement the input gear rotates at 80 rpm.

(ii) Calculate the speed of the output gear when the system has the lowest velocity ratio.

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..... **[2]**

Some candidates calculated the correct velocity ratio but then did not multiply it by the input gear speed. Many candidates did not demonstrate a clear understanding about which velocity ratio was appropriate to use.

Question 2 (a) (iii)

(iii) Calculate the difference in the speed of the output gear between the lowest and highest velocity ratios.

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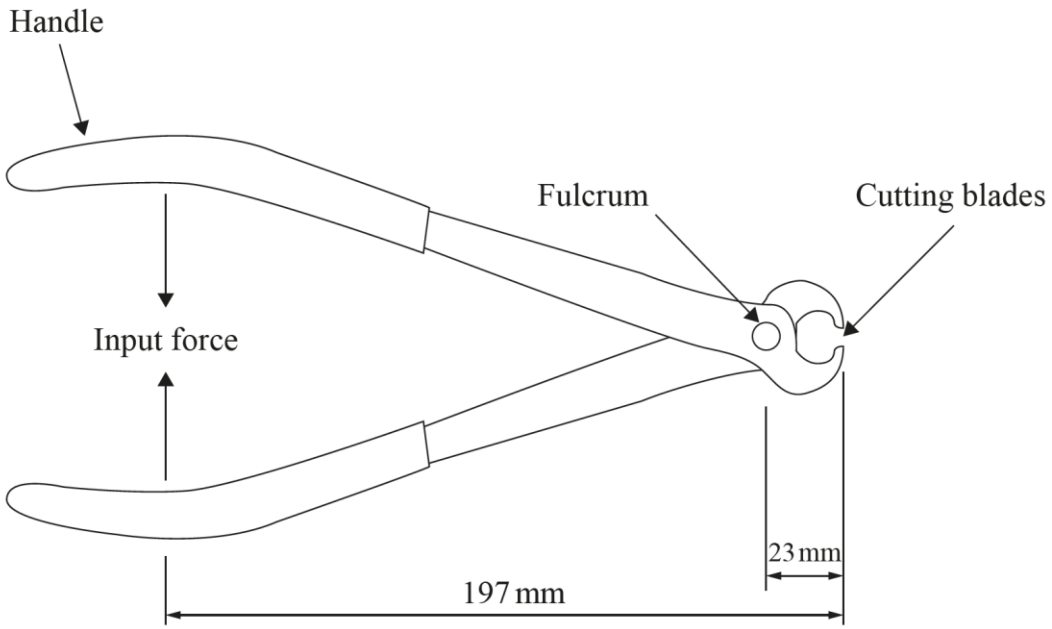
..... **[2]**

Some candidates who had not gotten Question 2 (a) (i) or Question 2 (a) (ii) correct got the correct answer here by starting their calculations again and getting it right. Conversely, there were a few who had gotten Question 2 (a) (i) or Question 2 (a) (ii) correct and then not used them in this question to get the correct answer.

Question 2 (b) (i)

(b) A pair of end cutting pliers is shown in the diagram below.



(i) The pliers are used to cut a piece of 1.5 mm diameter brass wire. Calculate the force required at the cutting blades to cut the wire if the maximum shear stress of brass is 270 N mm^{-2}.

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..... **[2]**

Many candidates gained full marks for this question. The most common errors were either using the diameter to calculate the area or multiplying the shear stress by the diameter.

Question 2 (b) (ii)

(ii) Calculate the total input force required on the handles to cut the wire.

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..... **[3]**

The most common mistake for this question was using the incorrect distance of 197mm to the fulcrum, rather than the correct distance of 174mm. A few of those candidates, using the Mechanical Advantage (MA) method, multiplied the output force by the MA rather than dividing it by the MA.

Question 3 (a)

3 A cyclist is travelling along a road at a speed of 25.2 kilometres per hour. The cyclist and bike have a combined mass of 73 kg.

(a) Calculate the combined kinetic energy of the cyclist and bike.

Give your answer in SI units.

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..... **[4]**

Most candidates were able to use the equation for kinetic energy correctly although many used the incorrect velocity of 25.5 km/h rather than converting it to $7ms^{-1}$. Some did not include the unit and some then chose the incorrect unit. A few candidates also tried to convert J to base SI units which was not necessary.

Misconception

SI units are not the same as SI base units.

Question 3 (b)

(b) Whilst travelling at 25.2 kilometres per hour the cyclist stops pedalling but then continues to roll along an upward slope in the road with a constant incline of 7° to the horizontal.

Using the conservation of energy principle and neglecting any frictional forces, calculate the distance that the cyclist will roll along the slope before stopping.

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..... **[4]**

Very few candidates used the conservation of energy principle as the question asked. Many also calculated the vertical height correctly but then did not calculate the distance along the slope.

Exemplar 2

$\frac{1}{2} m v^2 = mgh$

$\frac{1}{2} v^2 = gh$

$\frac{1}{2} \times 7^2 = 9.8h$

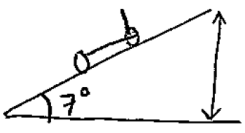
$\frac{49}{2} = 9.8h$

$\frac{49}{2} \div 9.8 = h$

vertical $h = 2.5m$

distance travelled $\sin 7 = 2.5$

dist travelled $= \frac{2.5}{\sin 7} = 20.51m$ **[4]**



The exemplar shows an excellent response using the conservation of energy principle to calculate the vertical distance and then using trigonometry to calculate the distance along the slope.

Question 4 (a)

4 A box of mass 14.5 kg is being pulled along a horizontal surface by a rope which is parallel to the surface. The tension in the rope is 85 N and the coefficient of friction between the box and the horizontal surface is 0.4.

(a) Calculate the normal reaction force on the box.

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..... **[2]**

A few candidates calculated the correct answer and then did a further calculation to get a different answer, so they didn't gain both marks. Some also multiplied the tension of 85N by 9,8ms^{-2} which was incorrect.

Question 4 (b)

(b) Calculate the frictional force between the box and the horizontal surface.

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..... **[2]**

Most candidates were able to correctly multiply their answer in Question 4 (a) by 0.4 and did well.

Question 4 (c)

(c) Show all forces acting on the box on the diagram below.

[2]

Most candidates answered this question reasonably well. The most common errors were labelling the frictional force as 0.4, the weight as gravity and the reaction force as upthrust.

Question 4 (d)

(d) Calculate the acceleration of the box.

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..... **[2]**

Many candidates did not use the resultant force to calculate the acceleration, and a large number incorrectly used the frictional force.

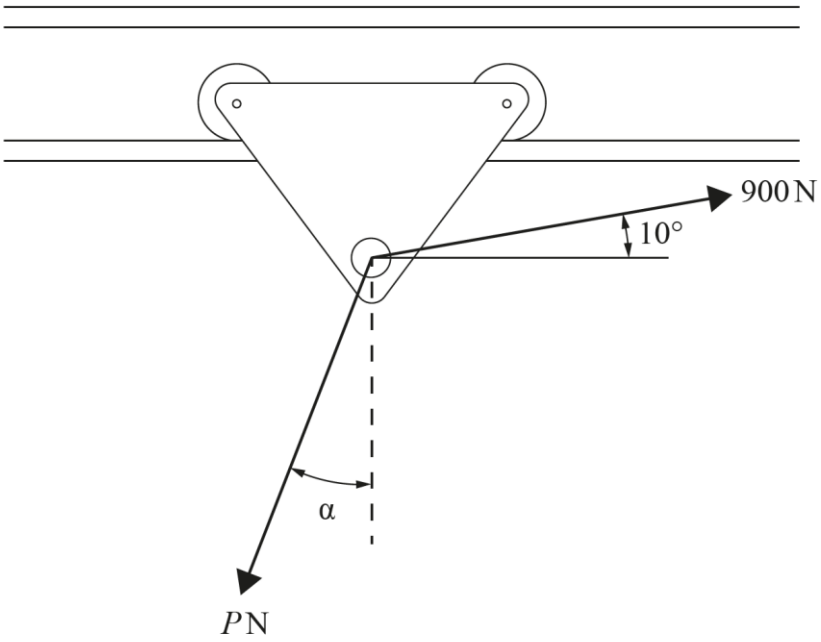
Misconception

The F used in the equation F = ma must be the resultant force. Many candidates incorrectly used the tension force of 85N, rather than the resultant force of tension force minus the frictional force.

Question 5 (a)

5

(a) The diagram below shows a smoothly running pulley system subjected to two forces of 900 N and P N.



Calculate the magnitude of force P and the angle α when the combined resultant of both forces is 2700 N in a vertical, downward direction.

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.....

.....

magnitude of P .....

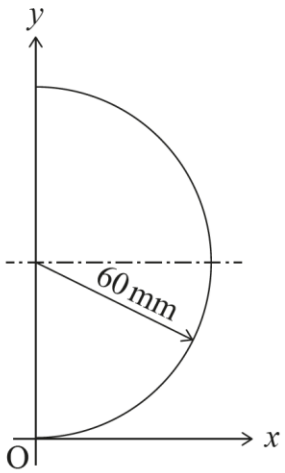
angle α .....

[6]

Most candidates achieved some marks for resolving the 900N force correctly into its horizontal and vertical components. However, many were not able to equate the total horizontal and vertical forces correctly.

Question 5 (b)

(b) The diagram below shows the surface of a semicircular plate with a radius of 60 mm aligned with a Cartesian coordinate system (x, y).



Calculate the coordinates of the centroid of the plate.

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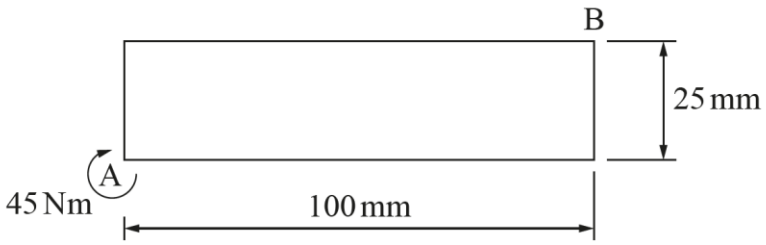
..... **[3]**

Most candidates answered this question reasonably well. The most common mistake was the use of 30mm for the y coordinate or writing the coordinates the wrong way around.

Question 5 (c)

(c) The plate shown in the diagram below has been subjected to several non-concurrent forces that have a resultant clockwise moment of 45 N m about corner A.



Calculate the magnitude and direction (up or down) of a vertical force to be applied to corner B so that there is no moment about corner A.

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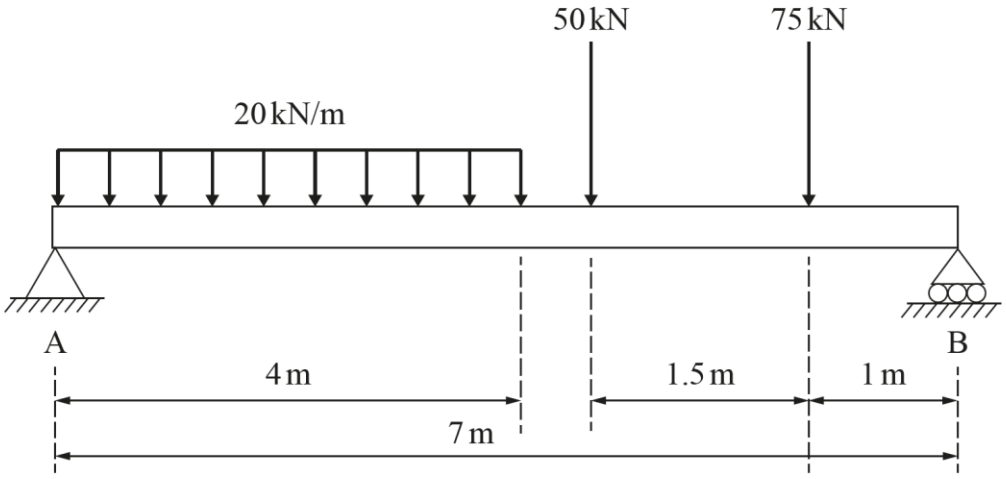
..... **[3]**

Many candidates used the incorrect distance to divide the moment by and quite a few incorrectly multiplied the moment by the distance. Many also did not state the direction of the force.

Question 6 (a)

6

(a) A simply supported beam of length 7 m shown below is subjected to a uniformly distributed load of 20 kN m^{-1} and two point loads of 50 kN and 75 kN. The weight of the beam can be neglected.



Calculate the reactions at supports A and B.

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.....

reaction at support A = ...

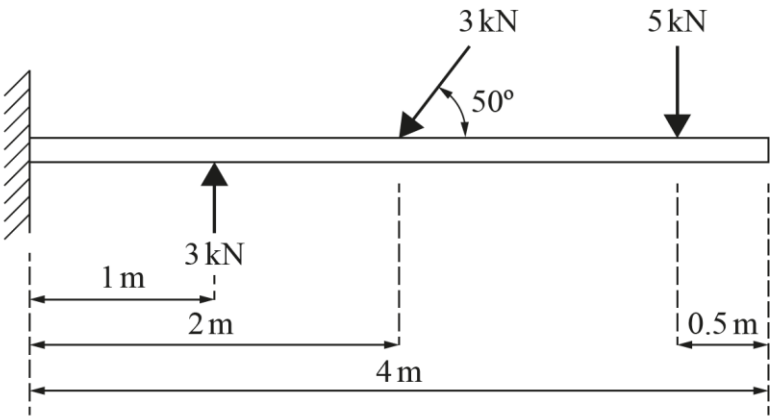
reaction at support B = ...

[5]

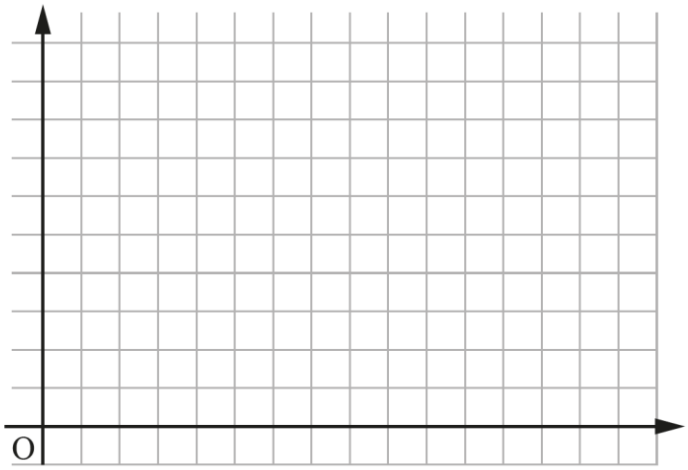
Many candidates who correctly converted the uniformly distributed load to a point load of 80kN then showed it acting at 4m from A rather than 2m. Many also did not multiply R_A and R_B by 7 when equating the clockwise and anticlockwise moments.

Question 6 (b)

(b) The diagram below shows a cantilevered beam subjected to three forces.



Draw a bending moment diagram for the beam on the grid below. Label the axis with appropriate units and values. The weight of the beam can be neglected.



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..... **[7]**

Most candidates found this question extremely difficult, and most only got 1 mark for correctly calculating the vertical component of the 3kN force. Those that attempted calculations did not make it clear where the bending moment was acting so were not able to achieve a mark for the plotting of their points. Many candidates labelled the y axis with Force or kN rather than (Bending) moment or kNm. Even those candidates who did well on this question often did not calculate the final bending moment at 4m.

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- the principles and methods of standardisation
- the best practices for collecting, storing and submitting evidence
- the common issues and challenges in internal assessment and how to avoid them.

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- the structure and content of the NEA units
- the assessment objectives and marking criteria for the NEA units
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