Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

Cambridge TECHNICALS

ENGINEERING

05822–05825, 05873

Unit 3 January 2020 series

Version 1

www.ocr.org.uk/cambridgetechnicals

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 can be downloaded from OCR.

You can now find the results awarded in 2018/19 for your Cambridge Technical subject area

As a centre approved to offer our Cambridge Technicals qualifications, we wanted to let you know we have now published the results awarded for 2018/19 Level 2 and 3 Cambridge Technicals (2016 suite). This information is helpful in allowing you to compare your centre achievements alongside national outcomes.

To browse to the document, log in to Interchange, click on 'Resources and materials>Past papers and mark schemes' in the left-hand menu and select 'Cambridge Technicals (2016) Results Awarded 2018/2019' from the drop down list.

ExamBuilder

Remember to keep your eye on ExamBuilder as we continue to update the bank of questions post exam series in line with our past paper policy. Therefore, you can be assured that new assessment material will continually be fed into ExamBuilder on an annual basis.

Online post series external feedback

Keep an eye out for updates on our post series feedback on Exams for Cambridge Technicals Webinars available in the autumn term.

Paper Unit 3 series overview

This Level 3 paper examined the principles of mechanical engineering. It followed a similar format to previous papers and included a number of recurring topics and question types.

The paper appeared to be accessible with most candidates attempting all questions. There appears to be improvement in candidates' responses to questions on beams and bending moment diagrams for many centres although many lower ability candidates continue to struggle with this topic. Candidates from some centres continue to score low marks on some recurring topics.

Candidates who performed well tended to:	***Candidates who did less well tended to:***
• use appropriate engineering language. • show clear working in all calculations. • convert units into standard units before carrying out any calculation. • use moment of area method to find coordinates of a centroid and use a tabular format to show workings clearly for these questions. • show familiarity with bending of beams including calculating reaction forces and drawing bending moment diagrams.	• make careless mistakes in calculations. • use incorrect engineering language. • score low marks on some recurring topics. • show a lack of awareness of recurring types of question.

Question 1 (i)

1 Fig. 1 shows a steel plate aligned within a Cartesian coordinate system (x. y). Units for both x and y values are centimetres (cm).

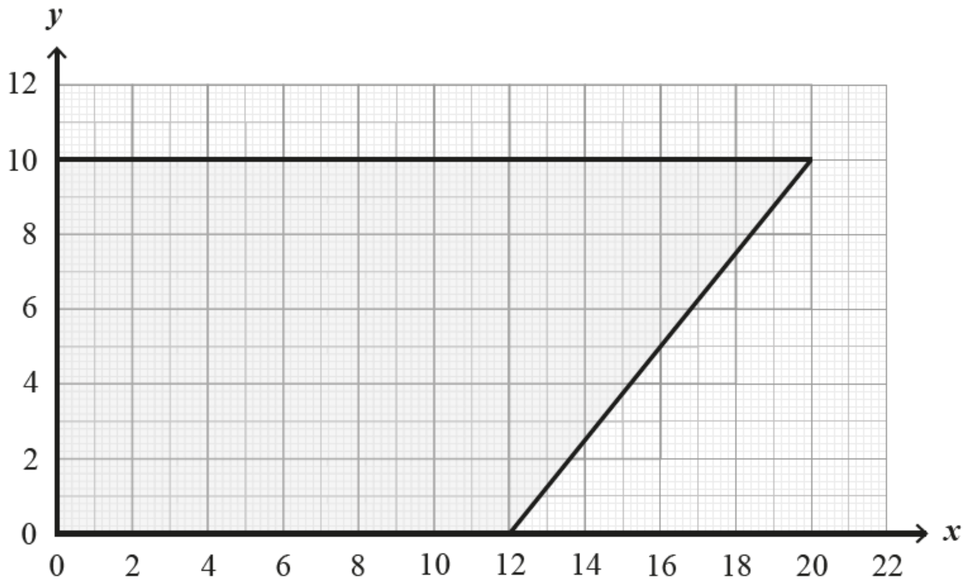

Fig. 1

(i) Calculate the area of the plate in square centimetres (cm^2).

....

....

....

.... **[2]**

Candidates were expected to calculate the surface area. Most successful candidates added together the areas of the rectangle and the triangle although the alternative method of subtracting the area of a triangle from that of a rectangle was equally valid.

In order to score both marks, the final answer needed to be in square centimetres. Most candidates scored both marks and many of these showed clear working. Some candidates gave their answer in square millimetres and scored just 1 mark.

Question 1 (ii)

(ii) The thickness of the plate is 0.5 cm and is made of steel with a density of 8 g cm^{-3}.
Calculate the mass of the plate in kilograms (kg).

....

....

....

.... **[3]**

Many candidates multiplied their area in cm (calculated in 1(i)) by the given plate thickness and density to calculate the correct answer.

Some candidates only calculated the volume or multiplied an incorrect volume by density to score 1 mark. Candidates who had a unit error in volume could score 2 marks.

Question 1 (iii)

(iii) Calculate the coordinates of the centroid of the plate.

....

....

....

.... **[5]**

A question of this type has appeared in a number of previous Unit 3 exam papers.

Many candidates used a tabular approach to present the key steps in their working, including areas and coordinates of centroids of each shape. These candidates had clearly used the moment of area method and most scored at least 3 marks. Most of these candidates went on to divide the sum of the moments of area by the total area to calculate the coordinates of the centroid correctly.

	AfL	Encourage candidates to use a moment of area method to find coordinates of centroid and to use a tabular format to show workings clearly.

Question 2 (a)

2 **(a)** An aluminium rod has a Young's Modulus of 70 GPa.

Calculate the stress in the rod when it is subjected to a strain of 0.15%.

Give the units for your answer.

....

.... **[2]**

Candidates were expected to use the relationship between stress, strain and Young's modulus.

Many candidates scored just 1 mark due to a 'power of 10' error.

Question 2 (b)

(b) A brass bolt of diameter 10 mm is subjected to a double shear force of 30 kN.

Calculate the shear stress in the bolt.

Give the units for your answer.

....

....

.... **[3]**

Candidates were expected to calculate the cross-sectional area of the bolt and to multiply this by 2 to find the shear area.

They were then expected to calculate the shear stress (= shear force ÷ shear area) and to include the correct unit.

Very few candidates included the factor of 2 for the shear area and so were limited to scoring just 1 mark for the cross-sectional area calculation.

Question 2 (c) (i)

(c) Fig. 2 shows a typical stress-strain graph.

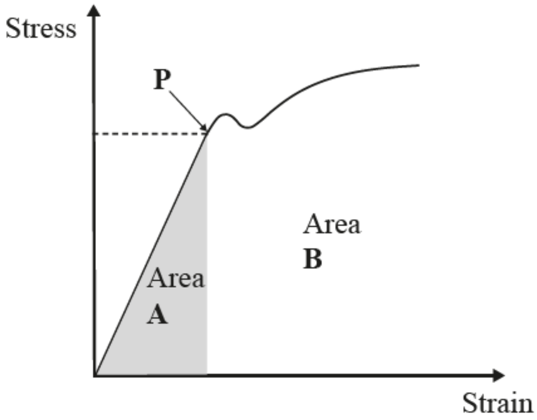

Fig. 2

State the names of the following.

(i) Point **P** on the graph.

.... **[1]**

Most candidates correctly identified this as the elastic limit, thereby securing 1 mark for this question.

Question 2 (c) (ii)

(ii) The shaded area **A** under the graph.

.... **[1]**

Some candidates identified this correctly as a region of elastic behaviour, securing 1 mark.

Question 2 (c) (iii)

(iii) The unshaded area **B** under the graph.

.... **[1]**

Some candidates identified this correctly as a region of plastic behaviour and were given the 1 mark.

Question 3 (a) (i)

3 **(a)** Fig. 3 shows a diagram of a compound gear train. The input gear, **A**, has 40 teeth and the output gear, **D**, has 20 teeth. The compound gear consists of gears **B** and **C** which rotate together on the same shaft. Gear **B** has 30 teeth and gear **C** has 80 teeth.

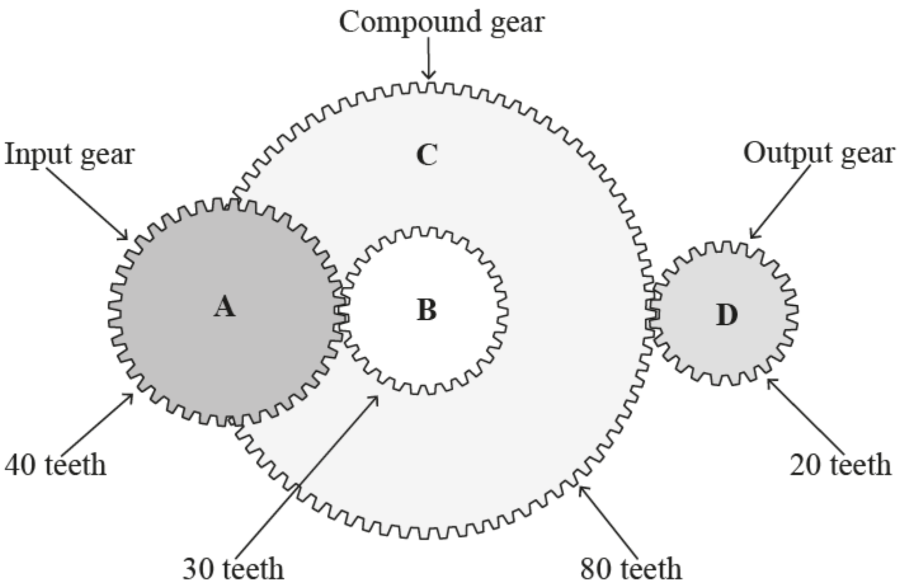

Fig. 3

(i) The input gear rotates at a speed of 90 rpm.

Calculate the rotational speed of the output gear.

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....

....

.... **[3]**

Many candidates calculated the overall velocity ratio and multiplied this by the rotational speed of the input gear to find the rotational speed of the output gear. This scored all 3 marks.

Some candidates showed evidence of calculation of velocity ratio (VR) and/or multiplied an incorrect VR by input speed to score 1 or 2 marks.

Question 3 (a) (ii)

(ii) Gear **A** is now replaced with a new gear, **E**.

Calculate the number of teeth required on gear **E** in order to achieve an overall Velocity Ratio (VR) of 6.

....

....

.... **[2]**

Many of those who scored 3 marks for (ii) used the VR formula correctly here to score 2 marks.

Question 3 (b)

(b) State the special feature of an application involving gears that would require a bevel gear arrangement.

....

.... **[1]**

Most candidates correctly stated (or implied) that a bevel gear arrangement allowed transmission between 2 rotating shafts at 90 degrees to each other (or other angles).

Question 3 (c)

(c) A belt and pulley system has a Velocity Ratio (VR) of 1.4. The diameter of the output pulley is 80 cm.

Calculate the diameter of the input pulley.

....

....

.... **[2]**

Most candidates multiplied the VR by the output diameter to calculate the correct input diameter.

Question 3 (d)

(d) Give **one** practical example of a mechanism that uses a Class Three Lever.

.... **[1]**

Many candidates identified a class three lever example correctly, and secure 1 mark.

Question 3 (e) (i)

(e) A Class Two Lever has a Mechanical Advantage (MA) of 2.05. The input force is 160 N.

(i) Calculate the maximum load that the lever can lift. Give your answer in Newtons.

....

.... **[1]**

Most candidates multiplied the mechanical advantage (MA) by the input force to calculate the correct value of maximum load.

Question 3 (e) (ii)

(ii) The input force is applied at a distance of 1.2 m away from the fulcrum.
Calculate the distance between the load and the fulcrum.

....

.... **[1]**

Most candidates divided the distance given in the question by the MA to calculate the correct value of distance between load and fulcrum.

Question 4 (a) (i)

4 **(a)** Fig. 4 shows a particle subjected to three forces.

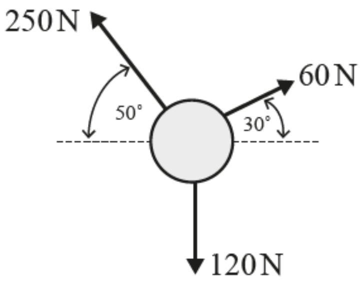

Fig. 4

(i) Calculate the magnitude of the resultant force acting on the particle.

....

....

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....

....

.... **[4]**

Many candidates calculated the horizontal and vertical components of the resultant correctly (by resolving in these directions) and then used Pythagoras' Theorem to calculate the single resultant. Most of these candidates showed clear working leading to the correct answer.

Some candidates scored just 1 or 2 marks by calculating the horizontal and/or vertical components correctly without using Pythagoras' Theorem. 1 mark could be scored by using Pythagoras' Theorem correctly but with incorrect components.

Question 4 (a) (ii)

(ii) Calculate the angle that the resultant force makes with the vertical.

....

....

.... **[2]**

Many candidates who scored full marks on (a)(i) also scored full marks here by calculating the angle correctly.

Some candidates scored just 1 mark by calculating the angle with the horizontal. Some candidates who scored 2 marks for (a)(i) scored 2 marks with error carried forward, or 1 mark with error carried forward but calculating the angle with the horizontal.

Question 4 (a) (iii)

(iii) At a particular time the particle is travelling with a speed of 1.2 m s^{-1}.

Calculate the instantaneous power of the resultant force at this time.

....

.... **[1]**

Most candidates used the relationship between power, force and velocity to calculate the correct answer. Many of these benefited from error carried forward.

Question 4 (b)

(b) A machine in a factory lifts a component with a mass of 4 kg through a height of 0.8 m from the floor to a bench. While moving the component the work done by the machine to overcome friction is 50 J.

Calculate the total work done by the machine to lift the component.

....

....

....

.... **[3]**

Many candidates calculated the increase in gravitational potential energy (GPE) and used this value together with the given value of work done by friction to calculate the correct value of work done by the machine.

Other candidates did not calculate the GPE correctly but scored 1 mark for using the work-energy principle correctly.

Other candidates who scored just 1 mark did so by just calculating the increase in GPE.

Question 5 (i)

5 A box of components in a factory is required to slide down a sloping ramp which is 4 m long. The box starts from rest at the top of the slope and slides with constant acceleration. An engineer is considering appropriate values for the coefficient of friction in order to decide on the material to be used for the ramp.

(i) In order to prevent any breakages the maximum speed of the box at the bottom of the ramp must not exceed 0.8 m s^{-1}.

Calculate the maximum acceleration of the box in this case.

....

....

.... **[2]**

Many candidates used the appropriate "SUVAT" equation correctly to score both marks.

Some candidates who did not calculate the correct value scored 1 mark by showing clearly their use of the appropriate equation and understanding of the terms.

Question 5 (ii)

(ii) The ramp has a rough surface and has a constant angle of 10° to the horizontal. The box has a mass of 15 kg and is subjected to a constant frictional force of F N as it slides down the ramp.

Draw a diagram showing all forces acting on the box.

[2]

Candidates were expected to show clear labelled arrows in the correct directions to score both marks. It was possible to score 1 mark by making a single error.

Some candidates did not draw arrows clearly and a small number omitted arrow heads entirely. Some candidates included a force down the slope which is incorrect so counts as 1 error.

Question 5 (iii)

(iii) Assuming that the box travels with the constant acceleration as calculated in part **(i)** calculate the magnitude of the frictional force F.

....

....

....

....

.... **[3]**

Many candidates correctly applied Newton's 2^{nd} Law down the slope (with the correct sin term) to calculate the correct answer.

Some candidates scored just 1 mark as they had a single sign error or sin/cos error (but not both).

Question 5 (iv)

(iv) Calculate the corresponding coefficient of friction, μ, between the box and the surface of the ramp.

....

....

.... **[2]**

Many candidates used the relationship between frictional force, normal contact force and coefficient of friction to calculate the correct answer.

Some candidates scored just 1 mark as they had omitted g or cos10 (but not both).

Question 5 (v)

(v) If the coefficient of friction, μ, is too high the box will remain stationary at the top of the slope.

Find the required range of values of μ so that the box will slide down the ramp but will not exceed the maximum speed of 0.8 m s^{-1}.

....

....

....

....

.... **[3]**

A small number of candidates calculated the new force with the box stationary and used this value to find the coefficient of friction before writing down the correct inequality.

Most candidates did not calculate the Force or the coefficient of friction when stationary so scored 0.

Question 6 (a)

6 **(a)** Name the type of beam with a fixed support at both ends.

.... **[1]**

Many candidates identified this beam type correctly, scoring 1 mark.

Question 6 (b) (i)

(b) Fig. 5 shows a beam of length 8 m simply supported at each end with supports A and B. The beam is subjected to two downward forces of 20 000 N and 60 000 N at the positions shown. The self-weight of the beam is negligible.

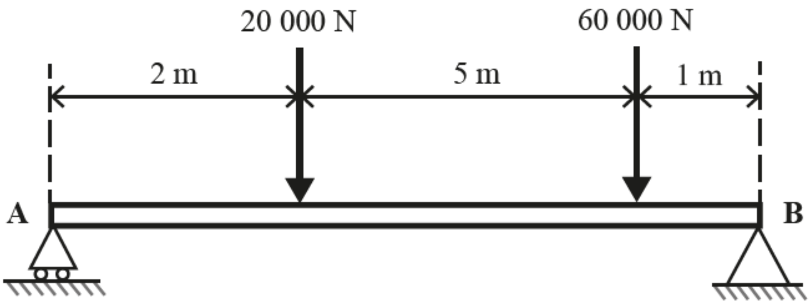


Fig. 5

(i) Calculate the vertical reaction forces at supports **A** and **B**.

....

....

....

....

....

.... **[4]**

Many candidates calculated both reaction forces correctly by taking moments about each end.

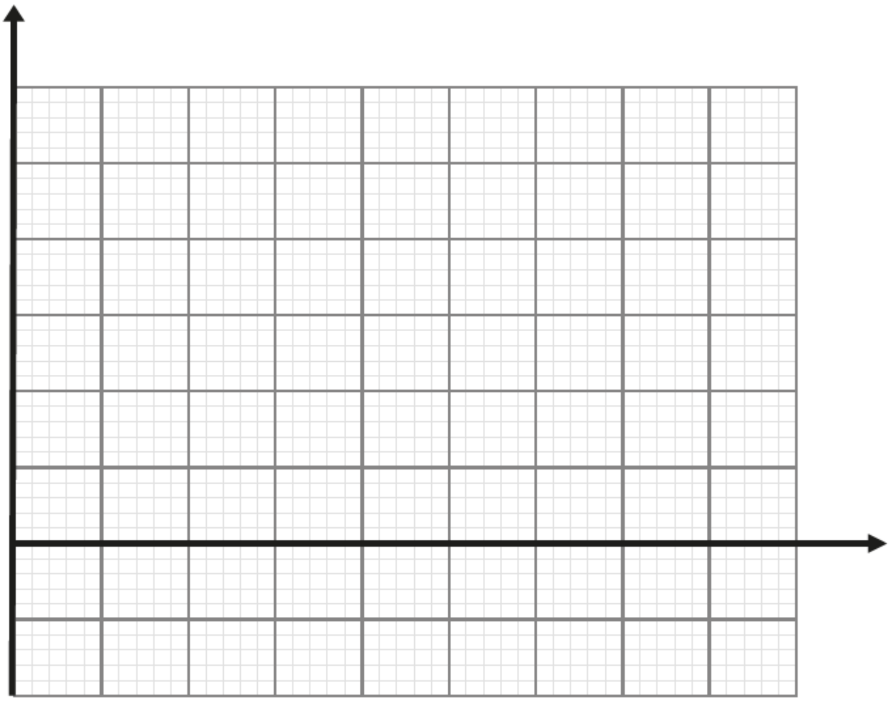
Some candidates took moments about one end to find 1 reaction force and then used vertical equilibrium to calculate the 2nd reaction force. Both methods followed through correctly gained full credit.

Some candidates who did not calculate either force correctly gained 1 or 2 marks by omitting a distance (usually the length of the beam) when taking moments.

Others gained one mark by using vertical equilibrium but with an incorrect reaction force.

Question 6 (b) (ii)

(ii) Draw a labelled bending moment diagram for the beam in Fig. 5 on the grid below.



[4]

Candidates were expected to draw the correct, linear diagram with the correct moments shown at 0m, 2m, 7m and 8m in order to score full marks. A linear diagram with a moment of 0 at both ends could score 1 mark, and extra marks were given for each of the other points (at 2m and 7m).

	AfL	Encourage candidates to become familiar with bending moment diagrams for beams. For beams loaded with point loads, the diagram will be linear. Encourage students to become familiar with common examples (e.g. simply supported beams).

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