CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 3 Summer 2023 series

Version 1

ocr.org.uk/cambridgetechnicals

Contents

Introduction 3

Unit 3 series overview 4

- Question 1 (i) 5
- Question 1 (ii) 6
- Question 1 (iii) 7
- Question 1 (iv) 7
- Question 2 (a) 8
- Question 2 (b) 8
- Question 2 (c) (i) 9
- Question 2 (c) (ii) 9
- Question 3 (a) 10
- Question 3 (b) (i) 10
- Question 3 (b) (ii) 11
- Question 3 (b) (iii) 11
- Question 4 (a) (i) 12
- Question 4 (a) (ii) 13
- Question 4 (b) 14
- Question 5 (a) (i) 14
- Question 5 (a) (ii) 15
- Question 5 (b) (i) 15
- Question 5 (b) (ii) 16
- Question 6 (a) (i) 17
- Question 6 (a) (ii) 18
- Question 6 (a) (iii) 18
- Question 6 (a) (iv) 19
- Question 6 (b) (i) 19
- Question 6 (b) (ii) 20

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:

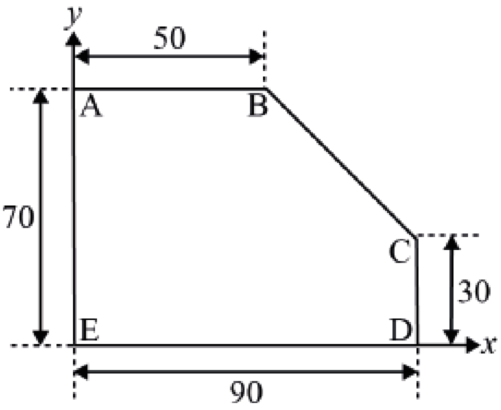
- be familiar with all the parts of the specification examined
- to show clear and legible workings especially for 2, 3, 4 and 5 mark questions
- to attempt all questions
- to be familiar with and make appropriate use of the formula booklet
- to be familiar with and make use of engineering language and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

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

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• 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 (i)

1 The shape of a steel plate of uniform thickness is shown below. All dimensions are in millimetres.



(i) Calculate the cross-sectional area of this steel plate.

....

....

....

.... **[2]**

Candidates were expected to calculate the area. Most responses scored 1 or 2 marks.

Question 1 (ii)

(ii) The steel plate is aligned within a Cartesian coordinate system, (x, y), with the origin at corner E and with side ED along the x-axis.

Calculate the coordinates of the centroid of the steel plate.

....

....

....

....

....

.... **[5]**

Candidates were expected to recall how to use the moment of area of uniform regular 2D shapes 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 of their rectangles/ triangles. A third mark was scored by some by dividing their sum of $a_i x_i$ (or $a_i y_i$) by their total area. Candidates who calculated one of the ordinates correctly could score a maximum of 4 marks.

Questions like this have been seen in several previous papers and it seems that many centres have made sure 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 1 (iii)

(iii) Explain what the centroid of the plate represents.

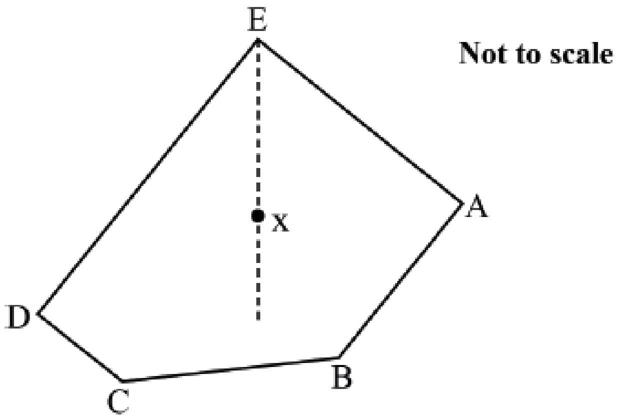
....

.... **[1]**

Candidates were expected to recall that the centroid represents the centre of mass/gravity. Alternatively, they needed to explain that the centre of mass is the single point where the mass of the body is 'considered to be' or the single point of the body from which the weight is considered to act. Most responses scored 1 mark.

Question 1 (iv)

(iv) The plate is suspended from corner E.



In the diagram **X** represents the centroid.

Calculate the angle between side EA and the vertical.

....

....

....

.... **[2]**

Candidates were expected to use trigonometry together with their earlier calculation of the coordinates of the centroid to calculate the required angle. Many candidates did this successfully, but many others did not. Some candidates scored 1 mark by calculating the angle between EA and the horizontal.

Question 2 (a)

2 **(a)** Explain what **concurrent forces** means.

....

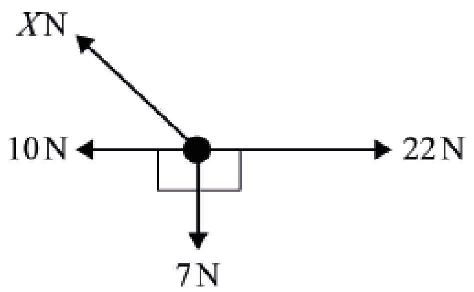
....

.... **[1]**

Candidates were expected to recall that concurrent forces act through the same point. Many candidates seemed unfamiliar with this concept.

Question 2 (b)

(b) Four co-planar forces are acting upon a body with magnitudes as shown.



Given the body is in equilibrium calculate the magnitude of force *X*.

....

....

....

....

....

.... **[3]**

Successful responses typically calculated the net horizontal force in the absence of X. They used this together with the net vertical force to calculate the magnitude of X using Pythagoras' theorem. Candidates who did not score full marks could score 1 mark for calculating the net horizontal force and a second mark for a good attempt to use Pythagoras.

Question 2 (c) (i)

(c) A structural column with a cross-sectional area of 5500 mm^2 is subjected to an axial compressive load of 2.5 kN.

(i) Calculate the stress in the column. Give the units for your answer.

....

....

....

....

....

.... **[3]**

Candidates were expected to use the defining equation for stress to calculate the stress. To score full marks, candidates needed to show both the correct value and the correct unit. Some responses did not include a unit and so scored 2 marks. Many candidates had a POT error and scored just 1 mark.

Question 2 (c) (ii)

(ii) The column is 3 m in length. Assuming Young's Modulus is 200 GPa calculate the change in length.

....

....

....

....

....

....

.... **[4]**

Candidates were expected to use the defining equations for Young's Modulus and strain to calculate the change in length. Candidates could score 1 mark for correct substitution into the defining equation for Young's Modulus equation and a further mark for calculating the value. A third mark could be scored for substituting into the strain equation and calculating a value. To score full marks, candidates needed to calculate the correct value and to show this with the correct units.

Question 3 (a)

3 (a) Identify **two** types of gear mechanisms that will allow the transfer of rotational motion between two adjacent shafts that are not in parallel alignment.

1 ....

2 ....

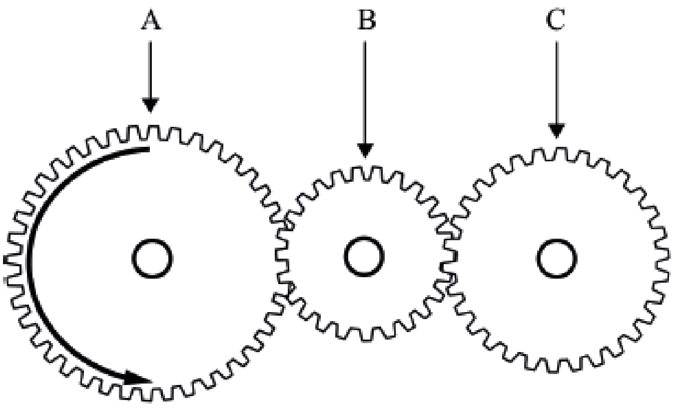
[2]

This question was answered well, many candidates were able to recall the appropriate gear types.

Question 3 (b) (i)

(b) A gear train consisting of three gears, A, B, and C is shown below.

Gear A is the input gear.



(i) Within a gear train it is often useful to associate each gear with a term that indicates its function or use.

Choose an appropriate term from the list below for gears B and C.

Compound gear	**Driver gear**	**Idler gear**
Output gear	**Transition gear**	

Gear B ....

Gear C ....

[2]

Many candidates used their knowledge of types of gear to answer this straight forward question successfully.

Question 3 (b) (ii)

(ii) If gear A has 25 teeth, gear B 12 teeth and gear C 20 teeth, calculate the total velocity ratio of the gear train.

....

....

....

.... **[2]**

Candidates were expected to use the ratio of input teeth to output teeth to calculate the velocity ratio. Note that some candidates used the inverse ratio, and this received no credit. Candidates who left their answer as a fraction could only score 1 mark.

Assessment for learning

Centres should make sure that when questions require calculations, answers should be given to the 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 (b) (iii)

(iii) Give **two** reasons why an idler gear may be used within a gear train.

1 ....

....

2 ....

....

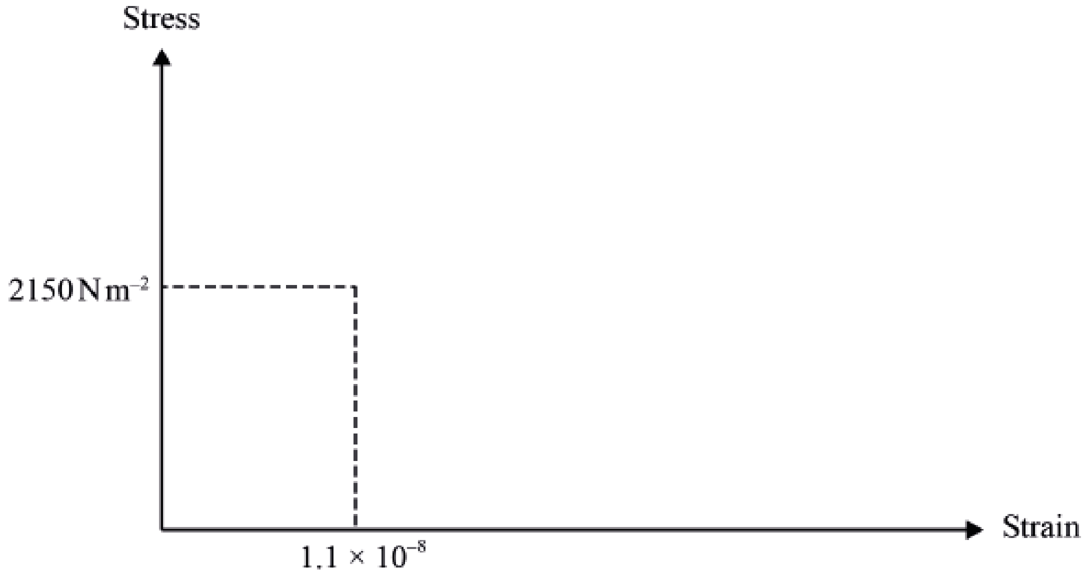
[2]

Candidates were expected to recall applications of gear types and to relate this to the specific arrangement given in the question (in this case idler gears.) Some responses made vague references to directions without being specific and this received no credit.

Question 4 (a) (i)

4 **(a)** **(i)** Sketch a typical stress–strain graph for a metallic material on the axes shown in **Fig. 1.** The values on the axes indicate the limits of the region where the Young's modulus remains constant (so Hooke's law applies).

Fig. 1



[2]

Candidates were expected to recall typical stress-strain graphs for different types of material. Many candidates attempted to draw the stress-strain curve for mild steel, and this was acceptable for both marks providing it was drawn correctly. The apparent focus on this unusual stress-strain curve by centres is surprising when most metallic materials used in engineering have a simpler curve.

Question 4 (a) (ii)

(ii) The table below lists the values for Young's modulus of four common metals.

Metal	**Young's Modulus**
Aluminium	$70 \times 10^9 \, \mathrm{N\,m^{-2}}$
Steel	$200 \times 10^9 \, \mathrm{N\,m^{-2}}$
Copper	$110 \times 10^9 \, \mathrm{N\,m^{-2}}$
Cast Iron	$120 \times 10^9 \, \mathrm{N\,m^{-2}}$

Using this table determine the most likely type of metal associated with the values indicated on the axes shown in **Fig. 1.**

Justify your answer.

....

....

....

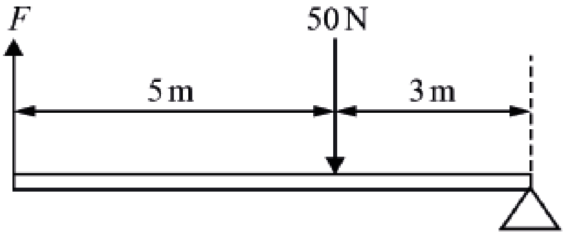
.... **[2]**

The correct material is steel, but responses could only be credited for stating this if they had calculated a value for Young's Modulus and compared this with the table values. Many candidates did this successfully and scored 2 marks. Candidates who did no calculation scored no marks. Some candidates did the calculation correctly but did not identify steel as the appropriate material. This scored 1 mark.

Question 4 (b)

(b) Calculate the minimum force F, required to lift the load of 50 N shown on this lever.

Assume that the weight of the lever is negligible.



....

....

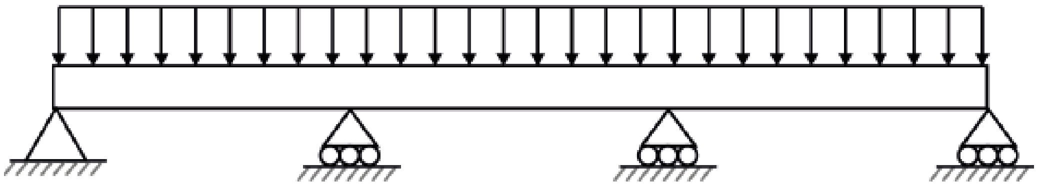
....

.... **[3]**

Most candidates who scored full marks did so by using the principle of moments (taking moments about the fulcrum). Some used the formula for Mechanical Advantage to get the same value. Many responses used 5m instead of 8m and this scored 0.

Question 5 (a) (i)

5 **(a)** A Uniform Distributed Load (UDL) is shown on a supported beam.



(i) State the name of this type of supported beam.

.... **[1]**

This question was straight forward and answered well by very many candidates.

Question 5 (a) (ii)

(ii) Give an example of what the UDL could represent.

.... **[1]**

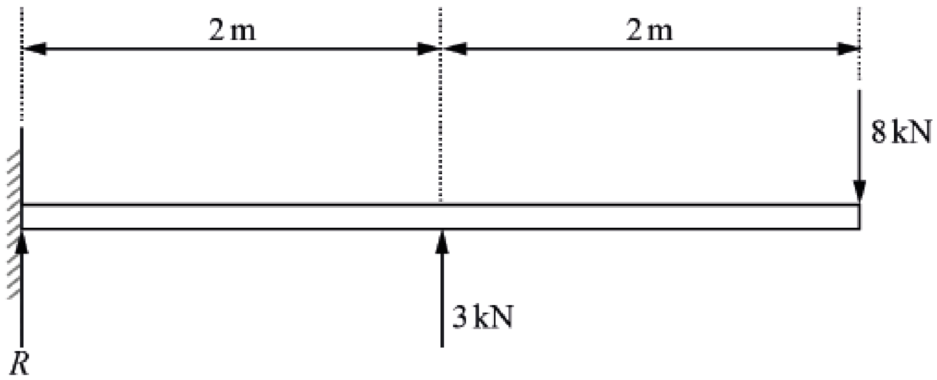
Many candidates were able to recall examples of different types of load on beams to gain the mark here.

Question 5 (b) (i)

(b) **Fig. 2** shows a cantilever beam attached to a wall.

The beam is subjected to two vertical forces of 3 kN and 8 kN.

Fig. 2



(i) Calculate the magnitude of the vertical reaction force, *R*, at the wall.

....

....

.... **[2]**

Candidates were expected to apply the equilibrium principle and to resolve forces vertically to find R. Very many candidates answered this question well.

Question 5 (b) (ii)

(ii) Draw a labelled bending moment diagram on the grid below for the cantilever beam shown in **Fig. 2**.

[5]

Candidates were required to recall the form of bending moment diagrams and to calculate values at key points. They were then required to sketch the bending moment diagram. A small number of candidates scored full marks. Many responses were given 1, 2, 3 or 4 marks for partially correct answers. Many candidates seemed unfamiliar with bending moments diagrams and scored 0 marks.

Assessment for learning

Centres should make sure that candidates are familiar with bending moment diagrams for the simple beam types and are able to calculate bending moment at key points in their diagrams.

Question 6 (a) (i)

6 **(a)** Two vehicles, A and B, are travelling in the same direction. Vehicle A is directly behind vehicle B. Vehicle A has a mass of 2600 kg and a speed of 15.6 $m\,s^{-1}$. Vehicle B has a mass of 1600 kg and a speed of 13 $m\,s^{-1}$.

Vehicle A then collides into the back of vehicle B. Immediately after the collision both vehicles continue to travel in the same direction but the speed of vehicle A has reduced to 9.4 $m\,s^{-1}$.

(i) Assuming that total momentum is conserved calculate the speed of vehicle B immediately after the collision.

....

....

....

....

.... **[3]**

Responses that were given full marks used the principle of conservation of momentum to calculate the speed of B. These responses usually had very clear workings that enabled them to calculate the correct value. Candidates who had laid out their working clearly but had a minor error could score 2 marks. Some candidates scored 1 mark for showing two correct terms. Many candidates made no attempt or gained no marks because value was not correct, and working was unclear.

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) (ii)

Immediately after the collision both vehicles slow down with a constant deceleration of $4\,\text{m}\,\text{s}^{-2}$ until they come to rest.

(ii) Calculate the distance travelled by vehicle A after the collision to when it comes to rest.

....

....

....

.... **[3]**

Responses which were given full marks identified and used the appropriate "SUVAT" equation to calculate the correct value. Candidates could score 1 mark for identifying the appropriate equation and a second mark for rearranging and substituting correctly.

Question 6 (a) (iii)

(iii) Calculate the magnitude of the braking force experienced by vehicle A while it is decelerating.

....

....

....

.... **[2]**

Candidates were expected to apply F=ma in the horizontal direction. Very many candidates answered this question successfully.

Question 6 (a) (iv)

(iv) Calculate the total work done by vehicle A while it is decelerating.

....

....

....

.... **[2]**

Many candidates were able to use the equation relating work done with force and distance travelled to calculate the work done to gain both marks here.

Question 6 (b) (i)

(b) A crane lifts a load with a mass of 150 kN to a height of 8.4 m above the ground. The cable holding the load then breaks and the load falls to the ground.

Air resistance can be neglected.

(i) Calculate the kinetic energy in the load when it reaches the ground.

....

....

....

.... **[2]**

Most candidates who scored full marks multiplied the force (i.e. the weight in Newtons) by the change in height to calculate the correct value. Some candidates equated the reduction in g.PE to the increase in KE to get the same correct answer.

Note that due to an inconsistency in the wording of the question stem (the first sentence referred to a crane lifting a load **with a mass** of 150 kN), full credit was also possible for candidates who used either 150kg or 150000kg instead of 150kN.

Question 6 (b) (ii)

(ii) Calculate the time it takes for the load to reach the ground.

....

....

....

....

....

.... **[3]**

Most candidates who scored full marks identified the appropriate "SUVAT" equation (or equations), rearranged and substituted correctly to find the correct value. Some candidates used a kinetic energy approach to find velocity which could also give full marks.

Supporting you

Teach Cambridge

Make sure you visit our secure website **Teach Cambridge** to find the full range of resources and support for the subjects you teach. This includes secure materials such as set assignments and exemplars, online and on-demand training.

Don't have access? If your school or college teaches any OCR qualifications, please contact your exams officer. You can forward them this link to help get you started.

Reviews of marking

If any of your students' results are not as expected, you may wish to consider one of our post-results services. For full information about the options available visit the OCR website.

Access to Scripts

For the June 2023 series, Exams Officers will be able to download copies of your candidates' completed papers or 'scripts' for all of our General Qualifications including Entry Level, GCSE and AS/A Level. Your centre can use these scripts to decide whether to request a review of marking and to support teaching and learning.

Our free, on-demand service, Access to Scripts is available via our single sign-on service, My Cambridge. Step-by-step instructions are on our website.

Keep up-to-date

We send a monthly bulletin to tell you about important updates. You can also sign up for your subject specific updates. If you haven't already, sign up here.

OCR Professional Development

Attend one of our popular CPD courses to hear directly from a senior assessor or drop in to a Q&A session. Most of our courses are delivered live via an online platform, so you can attend from any location.

Please find details for all our courses for your subject on **Teach Cambridge**. You'll also find links to our online courses on NEA marking and support.

Signed up for ExamBuilder?

ExamBuilder is the question builder platform for a range of our GCSE, A Level, Cambridge Nationals and Cambridge Technicals qualifications. Find out more.

ExamBuilder is **free for all OCR centres** with an Interchange account and gives you unlimited users per centre. We need an Interchange username to validate the identity of your centre's first user account for ExamBuilder.

If you do not have an Interchange account please contact your centre administrator (usually the Exams Officer) to request a username, or nominate an existing Interchange user in your department.

Active Results

Review students' exam performance with our free online results analysis tool. It is available for all GCSEs, AS and A Levels and Cambridge Nationals.

Find out more.

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on
01223 553998

Alternatively, you can email us on
support@ocr.org.uk

For more information visit
- **ocr.org.uk/qualifications/resource-finder**
- **ocr.org.uk**
- **facebook.com/ocrexams**
- **twitter.com/ocrexams**
- **instagram.com/ocrexaminations**
- **linkedin.com/company/ocr**
- **youtube.com/ocrexams**

We really value your feedback

Click to send us an autogenerated email about this resource. Add comments if you want to. Let us know how we can improve this resource or what else you need. Your email address will not be used or shared for any marketing purposes.

I like this **I dislike this**

Please note – web links are correct at date of publication but other websites may change over time. If you have any problems with a link you may want to navigate to that organisation's website for a direct search.

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT