OCR
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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Cambridge TECHNICALS

Unit 3 Summer 2019 series

Version 1

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.

Note to Centres

There were a number of centres who had selected an invalid combination of units or had claimed the wrong units for a candidate that prevented overall qualifications results being issued. Please note that it is the responsibility of the centre to check that correct units have been entered for certification claims. OCR cannot guarantee that the issuing of results in these circumstances will meet deadlines for UCAS confirmation.

Sector Update

Two key changes have occurred in relation to the Level 3 Technicals qualifications, both in relation to the examined units; firstly, an additional re-sit has been allowed, so candidates can have two further attempts at an examined unit if they wish to improve their result from the first attempt made. And secondly, a 'near pass' R grade has been introduced, which enables candidates who do not pass but achieve sufficient marks to gain some points for their examined unit outcome, which may mean that it is not necessary to re-sit the exam.

Paper Unit 3 series overview

This paper appeared to be accessible with most candidates attempting all questions. There is continued improvement in candidates' working for calculation questions, and some improvement in use of the correct engineering language in written answers. Some centres seem to be learning from the preceding Unit 3 examinations and preparing candidates well for recurring topics. Other centres, however, continue to score low or sometimes zero marks on some topics.

Candidates who performed well, tended to:	***Candidates who did less well tended to:***
• use appropriate engineering language. • show clear working in all calculations. • remember to convert units into standard units before carrying out any calculation.	• make careless mistakes in calculations. • use incorrect engineering language. • score low marks on some recurring topics.

Question 1 (i)

1 A rigid, rectangular plate, ABCD, with a length of 1.3 m and a width of 0.6 m is acted upon by three co-planar forces with magnitudes of 500 N, 700 N and 400 N as shown in Fig.1.

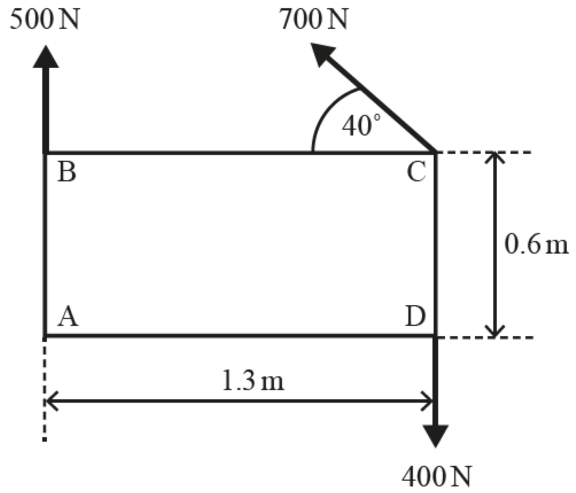

Fig. 1

(i) Resolve the force of 700 N into horizontal and vertical components.

Horizontal component .... **[1]**

Vertical component .... **[1]**

Candidates were expected to use trigonometry to calculate the horizontal and vertical components of the force. Many candidates did this successfully and scored both marks. Other candidates did not calculate either component correctly. Some candidates mixed up the horizontal and vertical components and 1 mark was awarded in this case.

	AfL	Encourage students to gain familiarity with resolving forces in particular directions.

Question 1 (ii)

(ii) Calculate the magnitude of the resultant of the three forces acting on the plate.

....

....

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....

....

.... **[3]**

Candidates were expected to calculate/state the resultant vertical and horizontal forces using their answers to 1(i) together with the other vertical forces. The overall resultant would then be calculated using Pythagoras' Theorem. Many candidates did this successfully and most candidates showed clear working leading to the correct answer. Error carried forward was allowed for incorrect answers to 1(i) and for an incorrect calculation of the resultant vertical force. Some candidates who did not score full marks scored 1 mark for calculating the resultant vertical force and 1 mark for using Pythagoras' Theorem.

Question 1 (iii)

(iii) Calculate the moment about corner A due to the three forces.

....

....

....

....

....

.... **[3]**

Candidates were expected to calculate the moments about corner A due to each of the 3 forces and to add these together (considering the direction). A minority of candidates calculated the correct value. Other candidates received credit for each correct term up to a maximum of 2 marks. This is a good illustration of the importance of showing working clearly.

Question 1 (iv)

(iv) An additional force of 500 N acting perpendicular to the side AD is to be applied so that the moment about corner A becomes zero. Calculate the horizontal distance from corner A at which this force acts and state its direction.

....

....

....

....

.... **[2]**

Candidates were expected to recognise that a moment equal in magnitude and opposite in direction to their 1(iii) is required. From this, the force can be calculated. In order to score both marks, candidates also needed to state the direction as "downwards" or to show this clearly. Many candidates who calculated the correct magnitude of force omitted to include the direction. Note that "clockwise" or "anticlockwise" are not appropriate terms when describing the direction of a force.

Question 2 (i)

2 Fig. 2 shows the shape and dimensions, expressed in **millimetres**, of the top surface of a component made from ABS plastic with a uniform thickness. The component is shown aligned within a Cartesian coordinate system (x, y) with the origin at point O.

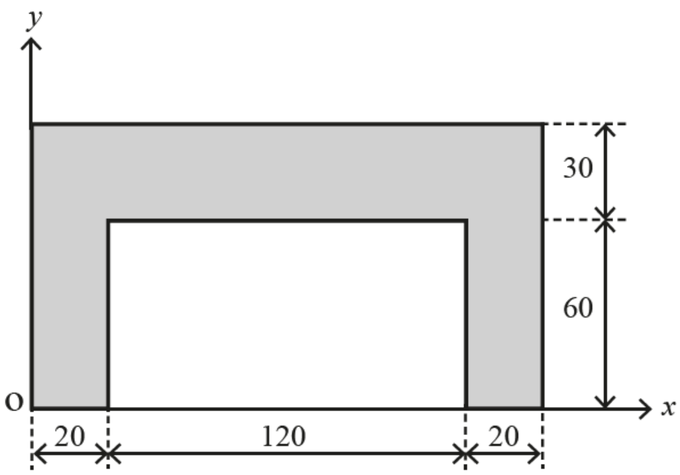


Fig. 2

(i) Calculate the surface area of the plastic shown in Fig. 2, expressing your final answer in **square centimetres**.

....

....

....

....

.... **[2]**

Candidates were expected to calculate the surface area. Successful candidates added together the areas of 3 rectangles or subtracted that of 1 rectangle from another. 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 2 (ii)

(ii) Calculate the coordinates of the centroid of the surface of the component as shown in Fig. 2.

....

.... **[4]**

A question of this type has appeared in several 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 students to use a moment of area method to find coordinates of centroid and to use a tabular format to show workings clearly.

Question 2 (iii)

(iii) The component is made from ABS plastic with a uniform thickness of 0.5 cm and a density of 1.05 g cm^{-3}. The cost of ABS plastic is £14 per kg. Calculate the cost of material in **800 components**.

....

.... **[5]**

There were some very good answers to this question that used clear working to show the steps taken by the candidate. Typically, these candidates began by calculating the volume of 1 component and then used this to find the mass in kg. They multiplied this by the number of components and finally by the cost per kg. Other candidates who also showed clear working but did not calculate the cost correctly were able to be awarded up to 4 marks.

Question 3 (a) (i)

3 **(a)** A class one lever with a length of 1.3 m is being used to lift a load with a mass of 950 kg. The load is at one end of the lever at a distance of 0.1 m from the fulcrum. The input force required to lift the load is applied at the other end of the lever. The mass of the lever can be neglected.

(i) Draw a labelled diagram showing the lever, with dimensions, fulcrum, input force and output force.

[2]

In order to score 2 marks, candidates needed to draw a diagram showing the lever and the input and output forces in the correct directions. They also needed to show the fulcrum and sufficient dimensions to confirm the relative positions.

Question 3 (a) (ii)

(ii) Calculate the magnitude of the minimum **output** force required to lift the load.

....

.... **[1]**

Candidates needed to calculate the weight due to the mass. Many candidates did this successfully. Other candidates overcomplicated the question and attempted to use moments to calculate an answer.

Question 3 (a) (iii)

(iii) Calculate the magnitude of the minimum **input** force required to lift the load.

....

....

.... **[2]**

Many candidates used the principle of moments successfully to calculate the answer correctly. Some candidates attempted to apply the principle but used incorrect distances. A very small number of candidates calculated Mechanical Advantage (MA) and used this to calculate the input force. This alternative method received full credit if completed correctly.

Question 3 (a) (iv)

(iv) Calculate the mechanical advantage of the lever.

....

.... **[1]**

Most candidates calculated the Mechanical Advantage correctly using their answers to 3a(ii) and 3a(iii).

Question 3 (b)

(b) A simple gear system comprises an input gear with 60 teeth meshed together with an output gear. The mechanical advantage of the system is 1.25. Calculate the number of teeth on the output gear.

....

.... **[1]**

Most candidates calculated the number of teeth correctly (number of input teeth x MA).

Question 3 (c)

(c) An engineer requires a gear system for a milling machine. The gear system must have the following features.

- Small and compact
- High mechanical advantage
- The axes of rotation of the input gear and output gear are perpendicular
- The direction of transmission is not reversible

Name the type of gear system that the engineer should select.

.... **[1]**

Most candidates named the type of gear correctly.

Question 3 (d)

(d) A belt and pulley system has an input pulley that rotates at 50 rpm and an output pulley that rotates at 100 rpm. The diameter of the input pulley is x cm and the diameter of the output pulley is $(2x – 30)$ cm. Calculate the value of x.

....

....

....

....

....

.... **[3]**

Many candidates calculated the diameter of the pulley correctly by using the Velocity Ratio (VR) formula to set up an equation in x and scored 3 marks. Others who did not calculate this correctly were given 1 or 2 marks as they presented their working clearly. A significant minority showed no workings and stated an incorrect answer so scored no marks.

Question 4 (a) (i) (a)

4 **(a)** Fig. 3a shows a cantilever beam of length 11 m attached to a wall. The beam has a uniform mass of 30 kg per metre length and is subjected to an upward force of 3000 N applied at a distance of 2 m from the wall and a downward force of 5000 N at a distance of 8 m from the wall.

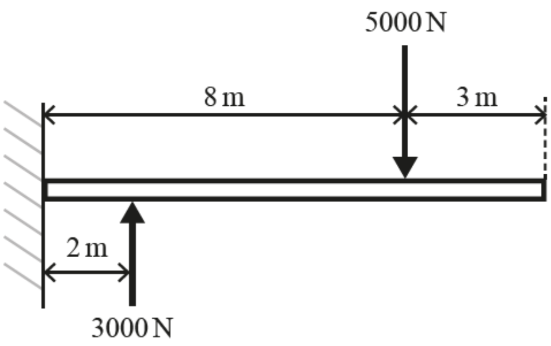


Fig. 3a

(i) The self weight of the beam is to be modelled as force acting at a single point.

(A) Calculate the magnitude of this force.

.... **[1]**

Candidates were expected to use the relationship W=mg to find the Force (W). Many candidates did this correctly. Some candidates attempted to use moments, and this gained no credit.

Question 4 (a) (i) (b)

(B) Indicate the position and direction of this force on Fig. 3b.

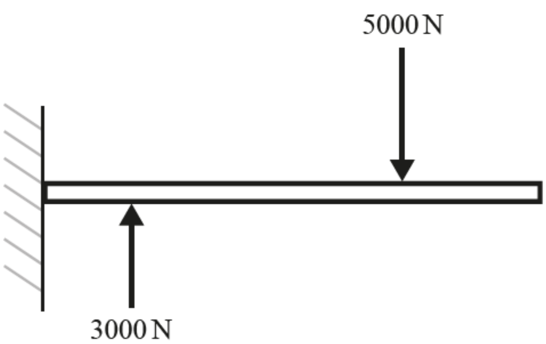


Fig. 3b

[1]

Most candidates added an arrow downwards and scored 1 mark.

Question 4 (a) (ii)

(ii) Name the type of support used to attach a cantilever beam such as this to a wall.

.... **[1]**

Candidates were expected to recall that this is a "fixed" joint/support.

Question 4 (a) (iii)

(iii) The self weight of the beam is one example of a uniformly distributed load (UDL). Provide another example of something that could cause a UDL.

.... **[1]**

In order to score this mark, candidates were expected to give an example of something that would cause a Uniformly Distributed Load (UDL) and to state what the load is applied to.

Question 4 (a) (iv)

(iv) Calculate the vertical reaction at the wall, stating the direction in which it acts.

....

.... **[2]**

Candidates needed to resolve forces vertically to find the magnitude of the vertical reaction and to state the direction of the force. Many candidates calculated the magnitude correctly but did not state the direction so scored just 1 mark.

Question 4 (b)

(b)

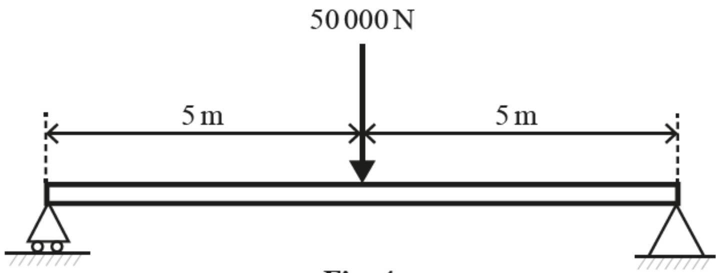
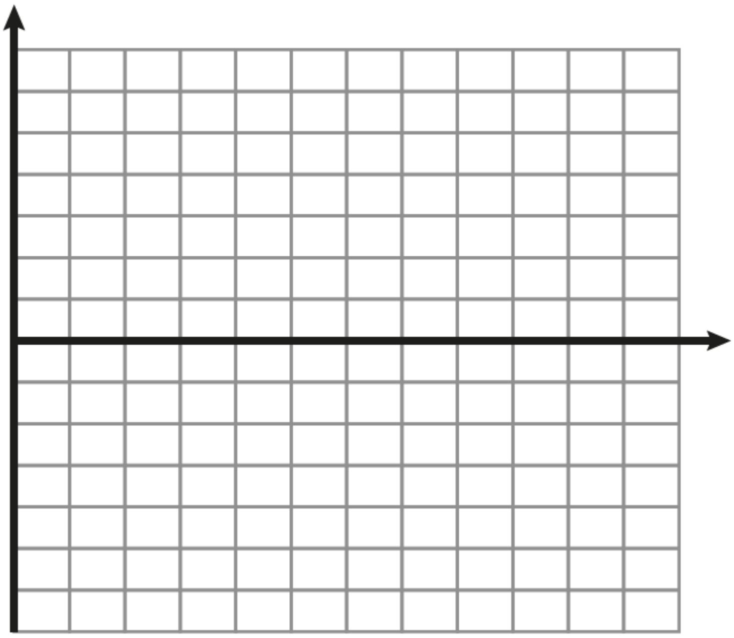


Fig. 4

Fig. 4 shows a simply-supported beam of length 10 m with a single downward force of 50 000 N acting at its centre. Draw a labelled bending moment diagram for the beam on the grid below. You may assume that the effect of the self weight of the beam can be neglected.



[3]

Candidates from a minority of centres scored 2 or 3 marks on this question. Candidates from most centres however scored 0. It was possible to score 1 mark by showing a linear diagram with moment of 0 at both ends.

	AfL	Encourage students to become familiar with bending moments diagrams for beams. For beams loaded with point loads the diagram will be linear.

Question 5 (i)

5 A car of mass 1800 kg is travelling along a rough horizontal road with a driving force of D N. The car is subjected to a force of 300 N due to the friction between its tyres and the surface of the road and an air resistance force of 200 N.

(i) Draw a diagram showing all the forces experienced by the car**.** (You may represent the car as a simple rectangle.)

[2]

Many candidates scored both marks on this question by showing each of the force arrows clearly with appropriate labels. Most candidates scored at least 1 mark.

Question 5 (ii)

(ii) The car accelerates uniformly from rest to a speed of 25 m s^{-1} in 20 s. Calculate the acceleration of the car during this period.

....

.... **[2]**

Many candidates used the definition of acceleration and calculated the acceleration correctly to score both marks. Some candidates attempted to use F=ma and scored no marks.

Question 5 (iii)

(iii) Using your answers to parts **(i)** and **(ii)**, calculate the magnitude of the driving force D N.

....

....

.... **[3]**

Candidates were expected to use F=ma with the given mass and acceleration calculated in 5(ii). Many candidates did this successfully with F as the resultant force. Clear working helped these candidates to score 3 marks. Some candidates used an incorrect value of Force together with the correct mass and acceleration to score 1 mark. Other candidates did not attempt to use F=ma but did calculate the resultant force correctly to score 1 mark.

Question 5 (iv)

(iv) Calculate the distance travelled during the 20 s period.

....

.... **[2]**

Candidates were expected to select the appropriate "suvat" equation and to substitute in the correct values. Many candidates did this successfully with clear working and scored 2 marks. Some candidates attempted to use a different suvat equation and this gained no credit.

Question 5 (v)

(v) The car is now modelled as a solid rectangular block with a mass of 1800 kg moving across a rough surface. There is a frictional force of 300 N between the block and the surface. Calculate the coefficient of friction between the block and the surface.

....

.... **[2]**

Candidates were expected to understand that the magnitude of the normal reaction is mg, and to use this together with the given frictional force to calculate the coefficient of friction. Most candidates did this successfully. Some candidates omitted "g" in their calculations and scored maximum 1 mark.

Question 6 (a) (i)

6 **(a)** A large body of mass 14 kg moving with a speed of 3 $m\,s^{-1}$ collides with a small stationary body of mass 2 kg. Immediately after the collision the large body continues to move in the same direction but with a reduced speed of 2.25 $m\,s^{-1}$.

(i) Calculate the kinetic energy of the large body before the collision.

.... **[1]**

Candidates were expected to use the equation for kinetic energy. Most candidates did this successfully.

Question 6 (a) (ii)

(ii) After the collision the small body moves in the same direction as the large body. Assuming that linear momentum is conserved, calculate the speed of the small body immediately after the collision.

....

....

....

.... **[3]**

Candidates were expected to recall the definition of momentum (p=mv) and the principle of conservation of momentum, and to use these to calculate the speed of the small body after the collision. Many candidates used clear working and calculated the correct answer. Some candidates received credit of 1 or 2 marks for calculating the momentum of one or both bodies, or for using the correct equation equating momenta before and after the collision.

Question 6 (a) (iii)

(iii) An **elastic** collision is one in which both kinetic energy and momentum are conserved. Using your results of parts **(i)** and **(ii)** determine whether or not the collision is elastic.

....

....

....

.... **[2]**

Candidates were expected to calculate the kinetic energy after the collision and compare this to the kinetic energy before the collision. To score both marks, they then needed to state a conclusion consistent with their calculation. Many candidates did this successfully. Some candidates merely stated a conclusion without supporting calculation and gained no credit.

Question 6 (b)

(b) A steel dart of mass 0.05 kg is thrown into a cork board with an initial speed of $10\,\mathrm{m\,s^{-1}}$. The tip of the dart becomes embedded in the board to a depth of 10 mm. By considering the work-energy principle, calculate the resistive force caused by the board.

....

....

....

.... **[2]**

Candidates were expected to calculate the reduction in kinetic energy and to equate this to the work done against the resistive force. Together with the equation for work done (WD = Fd) they were then expected to calculate the resistive force. Many candidates used clear working and calculated this correctly. Some candidates attempted to use a 'suvat' equation to find the acceleration and gained no credit as the question required them to consider "the work-energy principle".

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