CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 2 January 2021 series

Version 1

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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.

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Unit 2 series overview

Due to the circumstances this series was atypical, with a small cohort of candidates.

Despite the disruption to education during the past year, some candidates did very well on this paper. Most candidates attempted all the questions.

Candidates seemed familiar with most of the equations and formulae needed for this paper, but some candidates do struggle with the algebra skills needed to rearrange the formulae in order to complete calculations correctly. Candidates remembered both units and powers of ten better than in previous series.

This series the question on LO3 seemed the most challenging, as it was about capacitance, which is possibly less familiar to candidates. The most difficult question on the paper related to the discharge time for a capacitor.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• laid out calculations clearly. • recalled definitions and equations. • wrote explanations using clear scientific terminology.	• were unable to rearrange equations. • included insufficient detail in written answers.

Question 1 (a) (i)

1 **(a)** Name the measuring instrument used to measure:

(i) mass

.... **[1]**

Most candidates were able to name either scales or a balance for measuring mass.

Question 1 (a) (ii)

(ii) electric current

.... **[1]**

There was a common misconception that the device used to measure current is an ampmeter, rather than an ammeter.

Question 1 (b)

(b) Define 'intrinsic error'.

....

.... **[1]**

Although most were able to explain what is meant by error, only some candidates stated that an intrinsic error was one due to the measuring instrument.

Question 1 (c)

(c) A thermometer is made using liquid sealed into a thin glass tube inside an outer glass case, as shown in Fig. 1.

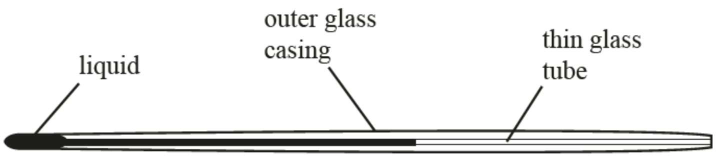

Fig. 1

Explain how to calibrate this thermometer using a different, accurate thermometer.

....

....

....

....

....

.... **[3]**

Most candidates suggested comparing this thermometer with an accurate thermometer, but only a few suggested repeating this at different temperatures. Candidates could have gained a mark for stating that the scale should be divided up proportionally between the two temperatures.

Question 2 (a) (i)

2 A cyclist travels from home to work.
Fig. 2 shows a distance–time graph for the journey.

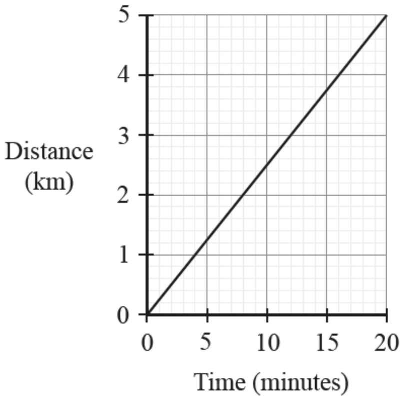

Fig. 2

(a) (i) Determine the speed of the cyclist in $km\,min^{-1}$.

speed = ... $km\,min^{-1}$ **[2]**

Most candidates correctly calculated the speed by using the end points of the line (5km in 20 minutes). Some candidates used the correct method but used other points on the line, which were difficult to read off accurately.

	AfL	When calculating a gradient of a line on a graph it is better to use points which are as far apart as possible. This reduces the uncertainty in the readings and provides a more accurate value.

Question 2 (a) (ii)

(ii) Convert this speed into ms^{-1}.

speed = ... ms^{-1} **[2]**

Most candidates realised that the value had to be multiplied by 1000 to convert from km to m. The number then needed to be divided by 60 to convert 'per minute' to 'per second'. Some candidates multiplied by 60 or used 3600 as the conversion factor.

Question 2 (b) (i)

(b) The cyclist returns home at the end of the day.

(i) Explain why the distance travelled by the cyclist is 10 km but their displacement is zero.

....

....

....

....

.... **[2]**

Most candidates gained a mark here for stating that displacement is the distance measured from the starting point. The second mark was given for saying that distance was a scalar or that displacement was a vector quantity, or for explaining the difference between scalars and vectors.

Question 2 (b) (ii)

(ii) The cyclist produces an average forward force of 800 N.

Calculate the work done by the cyclist in one day. Include the unit in your answer.

work done = ... **[3]**

Nearly all candidates used the correct equation [work done = force x distance] and gained at least one mark. Many remembered to convert km into m and including the correct unit [joule].

Question 2 (c)

(c) The next day there is a strong wind in the direction shown in Fig. 3.

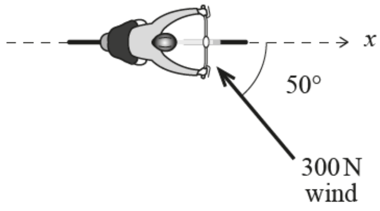

Fig. 3

Calculate the component of the wind force in the direction marked *x*.

wind force component = ... N **[2]**

Many candidates showed that they were able to resolve forces and realised that this question used cos 50° as direction *x* is adjacent to the angle.

	AfL	Remember that if you are resolving forces the value must always be smaller than the total force. The hypotenuse is always the longest side of a triangle.

Question 3 (a)

3 The engine control unit (ECU) in a car can be damaged by static electricity.

The circuits inside the ECU can be protected with a 0.8 μF capacitor.

(a) Define capacitance.

....

.... **[1]**

This question was not well answered. The definition of capacitance is stated in the specification and needs to be learnt. Many candidates gave vague qualitative answers about the amount of charge or energy able to be stored.

Question 3 (b)

(b) The 0.8 μF capacitor is uncharged. A static discharge delivers 2×10^{-5} C into the capacitor.

Calculate the potential difference across the capacitor.

potential difference = ... V **[3]**

It was good to see many candidates remembering to convert *μ*F to F before calculating the potential difference. Although many candidates gave the correct equation to use, they often got confused about which quantity was which. Several candidates substituted charge where they should have put capacitance and vice versa.

?	**Misconception**	*Q* is the standard symbol used to represent charge in Coulomb (C). *C* in the standard symbol used to represent capacitance in Farad (F).

Question 3 (c)

(c) The capacitor is made from two sheets of foil 0.5 mm apart.

Calculate the electric field strength between the foil sheets when the potential difference across the capacitor is 20 V.

field strength = ... $V\,m^{-1}$ **[2]**

Candidates found this calculation more straightforward than part (b), as many candidates gained both marks. The most common error was to forget to convert the distance from mm to m correctly.

Question 3 (d)

(d) The capacitor discharges and a small current flows into the ECU.

To prevent damage to the ECU, the discharge current must flow for at least 1 s.

Calculate the resistance required to make sure the current flows for at least 1 s.

resistance = ... Ω **[3]**

This was the most difficult question on this paper. Only a few candidates realised that they needed to use the time constant of the circuit and to apply the estimation that current flows for about 5 times the time constant.

Question 4 (a)

4 Many houses in the UK are built using bricks.

(a) Circle the correct word from the choice of three in each box to complete the sentence.

	malleable		compressive	
Brick is a ceramic which is	strong	when subjected to	tensile	forces.
	tough		torsional	

[2]

More candidates gained the mark for 'compressive' than for 'strong'.

?	**Misconception**	A tough material is one which absorbs a lot of energy by deforming plastically before failure. Ceramics are brittle materials. Both brittle and tough materials can be strong.

Question 4 (b) (i)

(b) Bricks above a window opening are laid on a steel beam.

Structural engineers calculate the load on the beam as the weight of the brickwork in the triangular area above the window as shown in Fig. 4.

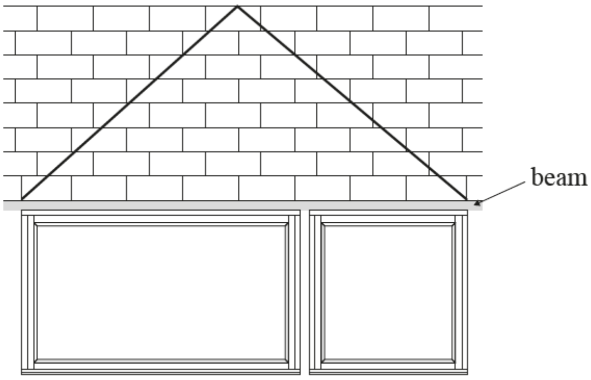

Fig. 4

(i) Each brick has mass 3.5 kg.

Show that the load on the beam above the window in Fig. 4 is approximately 1100 N.

[3]

Many candidates calculated the number of bricks in the triangle above the window by halving the product of 8 (the number of bricks along the horizontal base) and 8 (the number of bricks in the height). Candidates who tried counting the bricks in the triangle needed to be careful about which part-bricks to count as 36 bricks did not give an answer which rounded to 1100 N.

Question 4 (b) (ii)

(ii) The table in Fig. 5 shows the maximum load of three different beams from a given manufacturer.

Maximum load (N)		
Beam 1	**Beam 2**	**Beam 3**
500	1400	2000

Fig. 5

Explain which beam is most suitable for the window opening shown in Fig. 4.

....

....

.... **[2]**

Most candidates were able to choose an appropriate beam to use – either beam 2 or beam 3 were acceptable. They then needed to explain that beam 2 supported the required load without any extra expense or that beam 3 gave a larger safety margin.

Question 4 (b) (iii)

(iii) If an unsuitable beam is used, the beam may bend over time. This is a form of plastic deformation.

Describe, using ideas about atoms, how plastic deformation happens.

....

....

....

....

....

.... **[3]**

Most candidates gained at least 1 mark here for stating that plastic deformation is permanent, but in order to gain the other marks they needed to include explanation of what happens to the atoms. Some candidates described slip, while others stated that bonds between atoms were broken, but they also needed to state that bonds were re-formed with different atoms. Care with words in needed as on a macroscopic level plastic deformation is described in terms of not returning to the original shape, but on an atomic level, atoms do not change shape, so candidates needed to state that atoms do not return to their original position.

Question 4 (b) (iv)

(iv) To find the maximum load for each beam the manufacturer used destructive testing.

Give **one** reason why destructive testing was used to find the maximum load.

....

.... **[1]**

Many candidates were able to explain that destructive testing enabled the maximum load or stress to be measured, but only by allowing the material to fail or break.

Question 5 (a) (i)

5 Fig. 6 shows a central heating system. Water is heated by a boiler and flows through radiators which transfer energy to warm the surroundings.

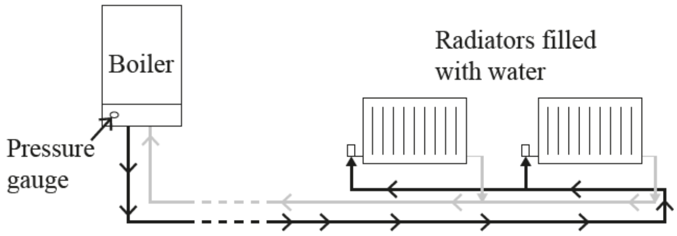

Fig. 6

(a) The pressure reading shown on the boiler is gauge pressure.

(i) Explain the difference between gauge and absolute pressure.

....

....

.... **[2]**

Most candidates gained a mark for explaining that absolute pressure included atmospheric pressure or by stating the relationship absolute pressure = gauge pressure + atmospheric pressure.

Question 5 (a) (ii)

(ii) The pressure gauge reads 1.5 bar (150 kPa). Atmospheric pressure is 1 bar (100 kPa).

State the absolute pressure in the central heating system.

absolute pressure = ... kPa **[1]**

Nearly all candidates were able to answer this question.

Question 5 (b) (i)

(b) After maintenance to the system, one of the radiators contains some air as shown in Fig. 7.

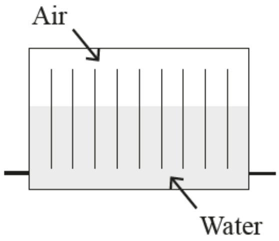

Fig. 7

(i) At 15 °C, the air has an absolute pressure of 220 kPa.

The temperature of the system increases from 15 °C to 55 °C.

Calculate the new absolute pressure of the air.

absolute pressure = ... kPa **[3]**

Many candidates correctly used the relationship P/T = constant, but the most common error was to omit the conversion of temperature into Kelvin before doing the calculation.

	AfL	The Gas Laws are only valid if the temperature is measured in Kelvin.

Question 5 (b) (ii)

(ii) There is a valve in the top of the radiator. There is a force on the valve due to the air inside the radiator.

Draw an arrow on Fig. 8 below to show the direction of the force.

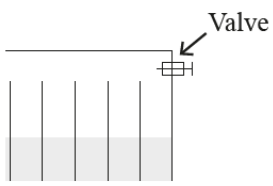

Fig. 8

[1]

Most candidates correctly drew an arrow pointing to the right.

Question 5 (b) (iii)

(iii) The valve is opened.

Explain why the air in the radiator comes out through the valve.

....

....

.... **[2]**

Most candidates gained 1 mark in this question for stating that the pressure inside the radiator is higher than outside, but to gain the second mark there needed to be some explanation of the pressure gradient or the force created by the difference in pressure.

Question 5 (b) (iv)

(iv) As the air comes out, the water moves up to fill the space.

Explain what will happen to the reading on the boiler's pressure gauge.

....

....

.... **[2]**

Many candidates correctly stated that the pressure decreases, but explanations were lacking. An explanation that there was now less matter in the same space was needed for the second mark.

Question 5 (c)

(c) The radiators must supply 11000 J of heat energy per second to keep the house at a constant temperature.

Determine the minimum required power output of the boiler and give the unit.

Assume no energy enters the system and no work is done by the system.

power output = ... **[2]**

Most candidates correctly realised that the power output was equivalent to the rate of energy supply and gave the correct unit – Watt.

Question 6 (a)

6 **(a)** Describe how the internal energy of an object is made up.

Use your ideas about particles.

....

....

.... **[2]**

Many candidates stated that the internal energy was related to the movement of particles and hence their kinetic energy. Only a few also included reference to the potential energy of the particles as well.

Question 6 (b) (i)

(b) A student is attempting to measure the specific heat capacity of aluminium.

Fig. 9 shows a graph of the results.

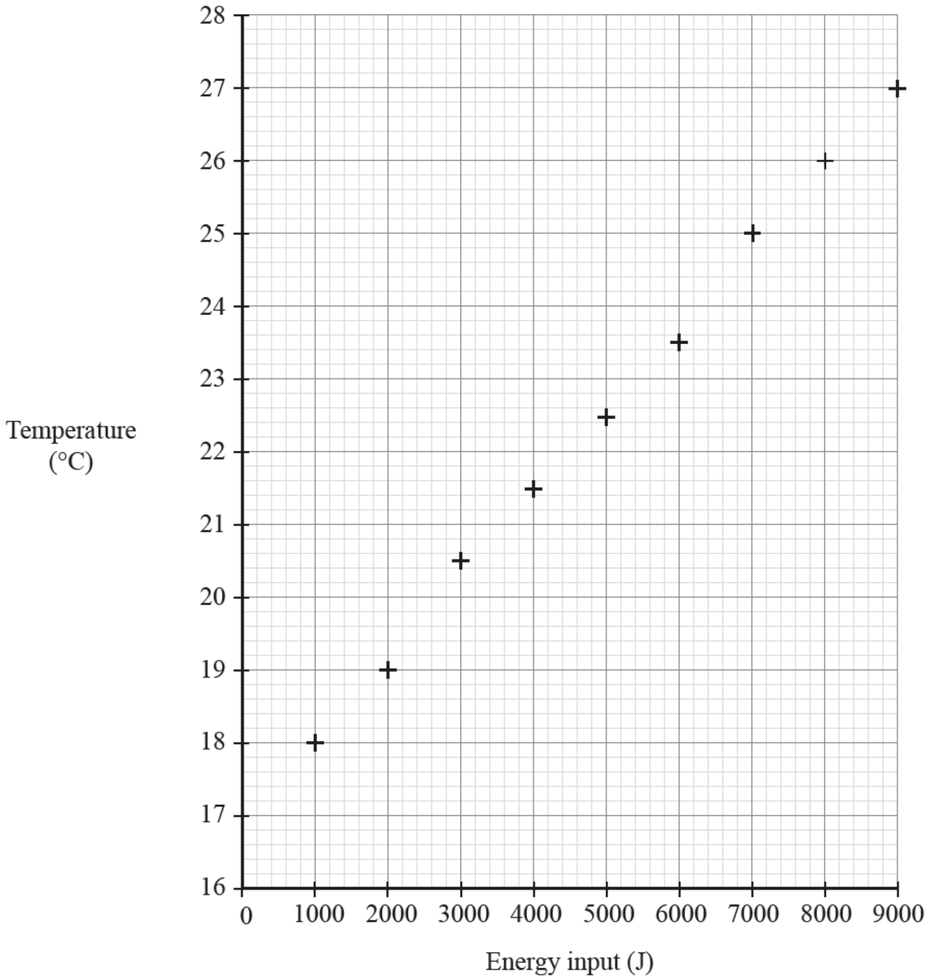

Fig. 9

(i) Draw a line of best fit on Fig. 9.

[1]

Many candidates were able to draw a reasonable line through the plotted points. Some tended to try to force their line through what looks like the origin of the graph, but is in fact (0, 16).

Question 6 (b) (ii)

(ii) Determine the specific heat capacity of aluminium from the gradient of the graph.

The student used an aluminium block of mass 1.1 kg.

specific heat capacity = ... J kg^{-1} K^{-1} **[3]**

Candidates tackled this problem in a variety of ways. Many used the equation $Q = mc\Delta\theta$, and then rearranged to find *c*, specific heat capacity. Common errors in this method were to use a value for temperature, rather than a change in temperature, or converting either temperature or temperature change into Kelvin, which is not necessary. The other method was to use the gradient of the line drawn on the graph, and if this is the case candidates need to read off points from their line, rather than plotted points, which may not actually be on the line. The two points used to calculate the gradient should be as far apart as possible to reduce the uncertainty in the value calculated.

?	**Misconception**	The Kelvin scale and the Celsius scale have equal sized units. A change of 1°C is equal to a change of 1 K. There is no need to convert a temperature change into Kelvin.

Question 6 (b) (iii)

(iii) The student read her thermometer to ±0.5 °C.

Calculate the relative error in the measurement of temperature when energy input was 1000 J.

relative error = ... **[2]**

Some candidates misinterpreted this question and calculated the uncertainty in the energy instead of the temperature reading. In order to find the relative uncertainty the absolute uncertainty should be divided by the true value, which in this case was 18°C.

Question 6 (b) (iv)

(iv) Explain why there is no change in latent heat during the experiment.

....

....

....

.... **[2]**

Most candidates identified that there was no change of state, so latent heat would not change and gained one mark. For the second mark they needed to explain the temperatures involved in this experiment were nowhere near the melting point of Aluminium or that only sensible heat was changing resulting in a temperature change.

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