Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

Cambridge TECHNICALS

ENGINEERING

05822–05825, 05873

Unit 2 January 2020 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 can be downloaded from OCR.

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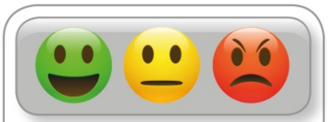

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Paper Unit 2 series overview

Candidates attempted all the questions and there was a good range of marks.

Multi-stage calculations were challenging to some candidates, many of whom seemed unfamiliar with the equations in the formula booklet. Recall of both definitions and equations which are not in the formulae booklet was poor. Unit conversion to SI units is improving but many candidates did not remember to use temperature in Kelvin for the gas law equations.

This session the question on LO2 seemed the most challenging, despite it covering some familiar concepts. Candidates struggled in particular with the addition of vectors using a diagram.

Candidate who did well:	*Candidates who did less well*
• laid out calculations clearly. • recalled definitions and equations. • wrote explanations using clear scientific terminology.	• showed no or poorly laid out working of calculations • were unable to rearrange equations or use their calculators correctly. • omitted converting units or used incorrect conversion factors.

	AfL	Formula booklet. Candidates should become familiar with the formula booklet before sitting the examination. This way they will be able to locate, and use required formulae quickly.

Question 1 (a)

1 **(a)** Give the SI base units for these derived quantities.

Draw lines to show which answer is correct.

One has been completed for you.

Derived quantity	**SI base units**
velocity	kg $m^2 s^{-3}$
acceleration	$m s^{-2}$
force	kg $m s^{-2}$
power	$m s^{-1}$

[2]

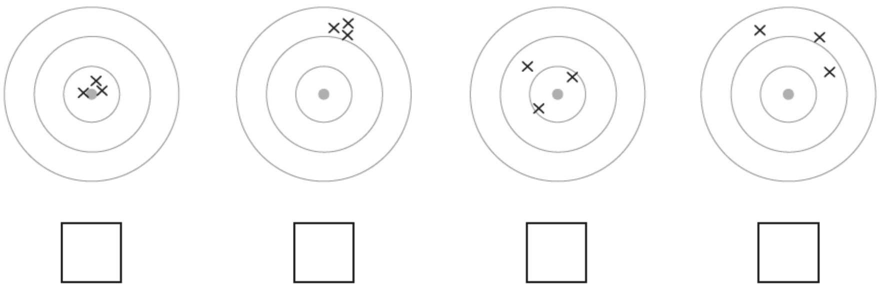
Many candidates were able to gain both marks for this question. Nearly all the candidates identified the correct unit for acceleration but some confused power and force.

Question 1 (b)

(b) Which diagram represents a precise but inaccurate set of measurements?

Tick (✓) **one** box.

Key
● true value
× measured value



[1]

In this question, most candidates identified the correct diagram showing precise but inaccurate measurements.

Question 1 (c) (i)

(c) (i) A barometer measures atmospheric pressure.

The barometer reads 102 kPa when the atmospheric pressure is 101 kPa.

Calculate the absolute correction for this barometer.

absolute correction = ... kPa **[2]**

Nearly all the candidates found the difference between the measured and true values, but in this specific question both marks could only be given if the final value included the negative sign.

Question 1 (c) (ii)

(ii) Explain why the pressure indicated on a barometer would not be a gauge pressure.

....

....

....

.... **[2]**

This question was aiming to test candidate's understanding of the term 'gauge pressure' and its relationship with absolute pressure and atmospheric pressure (specification ref 5.2), however it was not answered well. Candidates needed to explain that the pressure read from a gauge is actually the difference between the absolute pressure and the atmospheric pressure, and to explain that gauge pressure of the atmosphere would be negligible. A few candidates thought that this question was about the accuracy of the barometer and made comments about the difference between true and measured values.

Question 1 (d)

(d) An engineer measures resistivity of copper and obtains the value $1.61 \times 10^{-8}\ \Omega m$.

The accepted true value is $1.68 \times 10^{-8}\ \Omega m$.

Calculate the relative error in the engineer's result.

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

Most candidates showed that they knew how to calculate the relative error, but there were some power to ten errors and/or some arithmetic errors in some of the calculations.

Question 2 (a)

2 (a) Define the Newton.

....

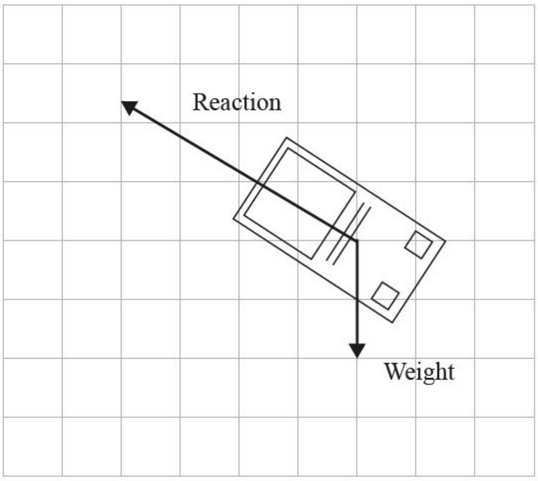
....

.... **[2]**

Most candidates gained one mark for stating that the Newton was the unit for measuring force, but only a few were able to recall the definition clearly (part of specification ref 2.3). Some candidates did give the SI base units for force (kg m s^{-2}) but no marks were given for this as it was part of Question 1(a).

Question 2 (b) (i)

Fig. 2 shows the forces acting on the bus.



Scale: 1cm = 60 kN

Fig. 2

(i) Determine the weight of the bus using information on the diagram.

weight = ... kN **[1]**

While many candidates correctly found the weight by realising that the length of the Weight arrow was two squares and multiplying 2 x 60 kN; some candidates overcomplicated the question and tried to do a calculation.

Question 2 (b) (ii)

(ii) Calculate the mass of the bus.

mass = ... kg **[2]**

Many candidates gained both marks for this question; some candidates forgot to convert kN to N and some multiplied (instead of divided) the weight by the acceleration of gravity.

	AfL	Unit conversions. Candidates should practice converting units using standard scientific notation (e.g. Mega, kilo, milli, nano, pico)

Question 2 (b) (iii)

(iii) Determine the resultant of the two forces by drawing **on** Fig. 2 and state the magnitude of the resultant force.

resultant force = ... kN **[3]**

Candidates should learn how to determine the resultant of two forces using a vector triangle (part of specification ref 2.1), but many candidates did not manage to draw either a vector triangle or parallelogram.

A common error was to complete a triangle by joining the ends of the existing arrows. There may have been some confusion with resolving vectors as some candidates resolved the Reaction force and then worked out what it was again.

Some candidates just added or subtracted algebraically the values of the forces. Most candidates who obtained the final correct answer, did so by using trigonometry or Pythagoras' Theorem so were able to gain 2 of the 3 marks available.

Question 2 (b) (iv)

(iv) The arrow for the weight force is drawn from the centre of gravity of the bus.

Define the term 'centre of gravity'.

....

....

.... **[2]**

This was another poorly answered recall question. Centre of gravity is defined clearly in specification ref 2.3, but most candidates referred to a point of balance or only mentioned mass, not weight.

Question 3 (a)

3 **(a)** An electric current is a flow of charge.

State the name of the SI unit for charge.

.... **[1]**

Many candidates were able to recall the unit for charge. Common errors included ampere, watt and farad. Some candidates put the symbol Q, and some correctly stated that charge was measured in ampere seconds, but this question required them to use the special name, coulomb.

Question 3 (b) (i)

(b) **(i)** Fig. 3 shows a cylinder of silicon with cross-sectional area $2.5 \times 10^{-4}\,m^2$.

The current in the cylinder is 1.5 nA.

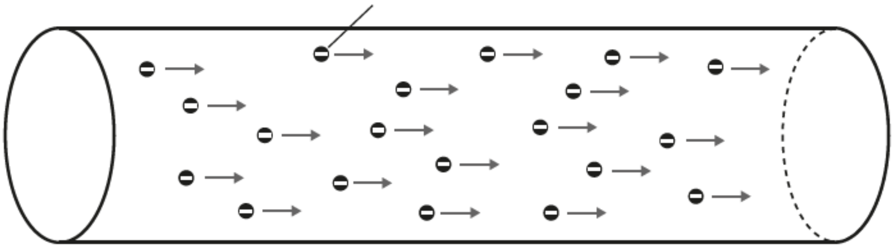


Fig. 3

The number density of electrons in silicon is $1.5 \times 10^{16}\,m^{-3}$.

The charge on an electron is $1.6 \times 10^{-19}\,C$.

Calculate the drift velocity of the electrons in the silicon.

drift velocity = ... ms^{-1} **[4]**

Candidates found this calculation difficult. Many candidates were able to choose the correct equation $I = nAve$, but some did not substitute the correct values for each term and/or were unable to rearrange the equation to give velocity, *v.*

A common error was to multiply all the given numbers together. Many candidates attempted to convert the current in nA to a current in A, but common errors included 10^{-6} or 10^{-3}

	AfL	Rearranging formulae. Candidates should have practice in rearranging formula to make a different letter or quantity in the original equation the subject.

Question 3 (b) (ii)

(ii) The number density of electrons in the silicon increases when the temperature increases.

Circle the correct word below to complete the following sentence.

The temperature coefficient of resistance of this silicon is ____________________ .

positive zero negative

[1]

This question was poorly answered with only a few candidates correctly stating that this was an example of a negative temperature coefficient. As the number density of electrons increases, it will become easier for current to flow, therefore the resistance will decrease, hence a negative coefficient.

Question 3 (c) (i)

(c) Fig. 4 shows the resistance of a thermistor at different temperatures.

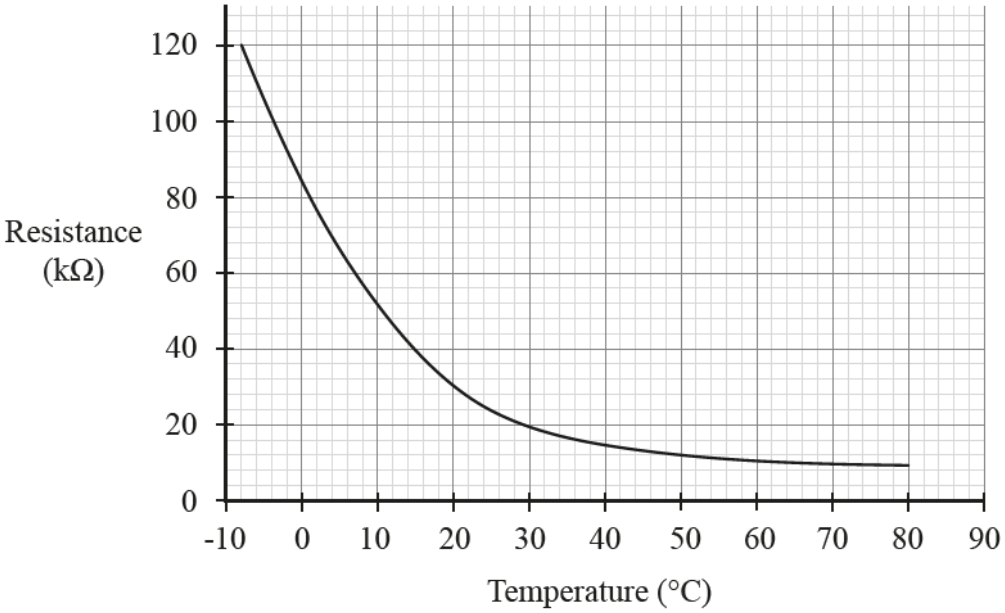


Fig. 4

(i) Use Fig. 4 to determine the resistance of the thermistor at 20 °C.

resistance = ... kΩ **[1]**

Question 3 (c) (ii)

(ii) Determine the change in resistance of the thermistor from 20 °C to 30 °C.

change in resistance = ... kΩ **[2]**

Almost all the candidates were able to read off the graph correctly and provide correct responses for part (i) and part (ii) of this question.

Question 3 (c) (iii)

(iii) A thermistor is needed in a circuit to control a central heating system.

The circuit must detect when the water temperature rises from a safe level around 60 °C to a dangerous level above 90 °C.

An engineer suggests that this thermistor is not suitable for this application.

Explain why the engineer is correct.

....

....

....

.... **[2]**

Many candidates made no reference to the information given in Fig 4 and gave an unsubstantiated reason why the thermistor could not be used, for example, the thermistor cannot be used in water, or the thermistor would melt.

Some candidates did not understand the concept of a thermistor being used as a sensor to control another circuit which operated the heater and hence stated that the thermistor would need to have an increase in resistance at higher temperatures.

Question 4 (a)

4 (a) Fig. 5 shows a crane lifting a load.

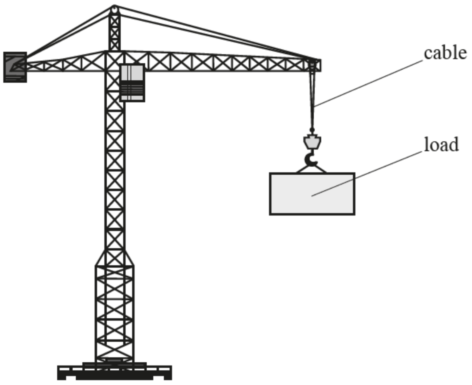


Fig. 5

The cable is made from metal.

Which **two** properties of metals are the main reasons why they are used to make cables?

Tick (✓) **two** boxes.

Brittleness ☐

Ductility ☐

Hardness ☐

Malleability ☐

Toughness ☐

[2]

Most candidates gave at least one correct response for this question.

Some candidates confused malleability and ductility.

Question 4 (b) (i)

(b) Fig. 6 shows the extension of the cable for different loads. The original length of the cable is 17.5 m.

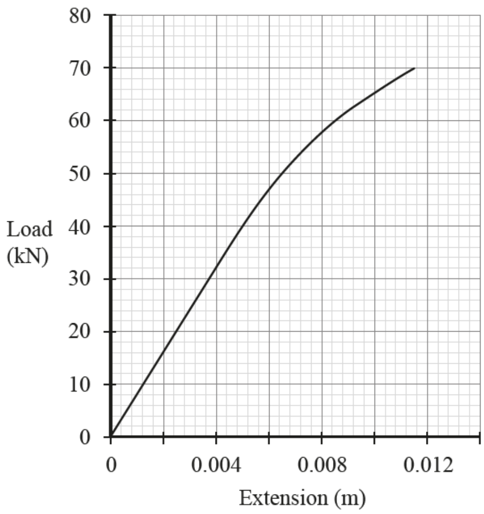


Fig. 6

(i) Determine the strain in the cable when the load is 20 kN.

Use information from Fig. 6.

strain = ... **[2]**

Most candidates knew how to calculate strain, but a few mis-read the graph. A common error was to add the extension onto the original length and then calculate strain by dividing the new length by the original length.

Question 4 (b) (ii)

(ii) The metal cable obeys Hooke's law up to a certain load limit.

Determine the load limit.

Show your method on the graph in Fig. 6.

load limit = ... kN **[2]**

Most candidates correctly identified that the load limit was at the end of the linear section of the graph.

A common error was to read off the load at the end of the line at 70 kN.

Question 4 (b) (iii)

(iii) Calculate the strain energy in the cable when the load is 30 kN.

Give the units for your answer.

strain energy = ... **[4]**

Very few candidates understood the concept of strain energy, and most just calculated the strain at a load of 30 kN. Specification reference 4.12 states that candidates should learn how to calculate strain energy from a force-extension graph by finding the area under the graph.

A few candidates correctly used the equation $energy = ½Fx$ instead. Some candidates realised that they needed to find a value for energy and used the equation $work\ done = Fx$. A mark was given here for using a consistent unit for energy so candidates who used a force in *Newton* and put a unit of *Joule* (J) were able to gain a mark.

Question 5 (a)

5 **(a)** Give **two** states of matter that are 'fluids'.

1 ....

2 ....
[2]

Most candidates answered this question correctly, but some gave examples of fluids, such as water and oil, but this was not what was asked for in the question.

Question 5 (b)

(b) State Archimedes' principle.

....

....

....

.... **[2]**

Most candidates struggled to recall Archimedes' principle correctly. Many of them realised that is was to do with water being displaced when an object is immersed in water, but tried to describe how to find the volume of an irregular object rather than state that it is to do with the up thrust or force on an immersed object.

Only a few candidates mentioned that is was equal to the weight of the displaced water, many said mass or volume.

Question 5 (c)

(c) A boat of mass 2500 kg is floating in the sea.

Calculate the volume of water it displaces.

The density of seawater is 1020 kg m^{-3}.

volume = ... m^3 **[3]**

Many candidates calculated the correct value but did not lay out their calculation clearly. Others just multiplied all the given values together

Question 5 (d)

(d) When the boat travels slowly the water moves past it in streamline flow.

The boat accelerates and the water moves in turbulent flow.

Explain how the movement of the water particles changes when in turbulent flow.

....

....

....

.... **[2]**

Most candidates gained one mark here for explaining that in turbulent flow the particles move in random directions, but only a few gained the second mark for adding that the particles would all be travelling at different velocities as well as different directions.

Question 5 (e)

(e) The boat is driven by 48 V electric motors that draw a maximum current of 85 A.

Calculate the maximum power output of the electric motors in kW.

power = ... kW **[2]**

Most candidates correctly calculated the power by multiplying the potential difference by the maximum current to give 4080 W, but in order to gain the second mark they needed to convert this to kW by dividing the answer by 1000.

Question 5 (f)

(f) With an output power of 3.1 kW, the boat travels at a steady speed.

The electric motors are 85 % efficient at this power output.

The battery stores 30 kWh of energy.

Calculate the time in hours it would take to empty a fully-charged battery.

time = ... hours **[3]**

Candidates struggled with this multi-stage calculation, but most managed to gain at least one mark for the correct use of the relationship, $energy = power \times time$, to find a time in hours.

Common errors included calculating the input power as less that the output power by multiplying 3.1 kW by 85%, rather than dividing 3.1 by 85%. An alternative incorrect method was to multiply 3.1 kW by 115%, but this is not a correct method.

Question 6 (a)

6 (a) Complete the sentence below.

Absolute zero is the temperature at which all substances …

.... [1]

This question required candidates to understand that at absolute zero substances have minimum internal energy. It is incorrect to say that they have zero internal energy as there will still be some potential energy due to the position of the particles, but the particles will have zero kinetic energy at absolute zero.

Question 6 (b)

(b) Convert 18 °C to kelvin.

temperature = ... K [1]

While most candidates were able to correctly calculate 18°C to 291 K, there were some candidates who multiplied or subtracted 18 by 273, and some who did not recall 273 K and used some other number.

Question 6 (c)

(c) A child is carrying a helium balloon.

The temperature is 18 °C.

The volume of the balloon is 5.0 litres.

The pressure in the balloon is 105 000 Pa.

1 litre = 0.001 m^3

The molar gas constant is 8.31 $J mol^{-1} K^{-1}$

Calculate the number of moles of helium gas in the balloon.

number of moles = ... **[4]**

Despite the previous question asking candidates to convert 18°C to Kelvin, many candidates still used 18°C in this calculation. All the gas equations require temperature to be in Kelvin.

Some candidates also did not convert the volume in litres to m^3, even though the conversion factor was given.

Many candidates did identify that they needed to use the equation $PV = nRT$, but some were unable to rearrange it to find *n*.

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