CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 2 January 2022 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.

Unit 2 series overview

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

Candidates seemed more familiar with the equations in the formula booklet and many succeeded with the multi-stage calculations. Converting to SI units before calculating was often omitted.

Written responses often lacked clarity and some candidates did not correctly use scientific terminology.

The question on LO2 seemed quite challenging again, despite it covering some familiar concepts.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• Performed complex calculations involving multiple stages, rearrangement of equations and conversion to SI units. • Used appropriate scientific terminology in written responses. • Made sure that they had read the question carefully and used all the information given.	• Performed simple calculations correctly. • Wrote vague explanations lacking scientific vocabulary.

Question 1 (a) (i)

1 **(a)** Name the SI base unit for:

(i) electric current

.... **[1]**

Most candidates knew that the SI base unit for current is the amp or ampere.

Question 1 (a) (ii)

(ii) luminous intensity

.... **[1]**

The base unit for luminous intensity is not so well used, so many candidates did not know that it is the candela. Common incorrect responses included the henry or the lumen.

Question 1 (b) (i)

(b) **(i)** Engineer **A** measures the value of g, the acceleration due to gravity.

The engineer's result is $9.95\,\text{m}\,\text{s}^{-2}$.

The accepted true value for g is $9.81\,\text{m}\,\text{s}^{-2}$.

Calculate the relative error in the engineer's measurement.

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

Most candidates were able to calculate the relative error in the value. Some candidates only performed half the calculation. The absolute uncertainty is calculated by subtracting true value from the measured value. Some candidates only found the ratio of the measured value to the true value.

Question 1 (b) (ii)

(ii) Four other engineers also measure *g*.

All results are shown in the table below.

Complete the **three** missing values in the table.

Engineer	Value for *g* ($m\,s^{-2}$)	Deviation	Deviation^2
A	9.95	+0.15	+0.0225
B	9.80	0	0
C	9.65	−0.15	
D	10.00	+0.20	
E	9.60		+0.0400
	Mean = 9.80		

[2]

Many candidates incorrectly gave a positive value for the deviation. The previous rows of the table show clearly that the values smaller than the mean value should give a negative value for deviation. The square of any number will always give a positive value, so the two values in the Deviation^2 column should both be positive. Some candidates decided to use true value of *g* (9.81), rather than the mean value (9.80) given at the bottom of the table.

Question 1 (b) (iii)

(iii) The standard deviation is 0.158.

Calculate the standard error of the mean.

Use the equation: standard error of the mean $= \dfrac{\text{standard deviation}}{\sqrt{\text{number of measurements}}}$

standard error of the mean = ... **[2]**

Most candidates were able to perform this calculation correctly, but some only gave their final answer to 1 significant figure. The value of standard deviation is given to 3 significant figures so an appropriate number of significant figures for the answer is also 3, but in this paper it is common practice to give all numerical answers to 2 significant figures unless it is inappropriate to do so.

Question 2 (a) (i)

2 In 2012, a skydiver jumped from the edge of space.

(a) (i) During the fall, the skydiver experienced forces that changed their motion.

What property of an object resists any change in its motion?

Tick (✓) **one** box.

Density	Mass	Speed	Weight
☐	☐	☐	☐

[1]

Some candidates were able to answer this correctly, but many seemed unaware that mass can be defined as a measure of an object’s resistance to change in velocity [see spec ref 2.2].

Question 2 (a) (ii)

(ii) The combined mass of the skydiver and their spacesuit was 110 kg.

Explain how weight is different to mass.

....

....

.... **[2]**

This question was not well answered as many candidates did not clearly state that weight is a force, so were unable to gain both marks. Candidates seemed unable to explain the concept using precise scientific vocabulary and some got the two properties mixed up.

Please see Fig. 1 graph on page 9, which we have moved to be near Question 2 (c) commentary for this Examiner's report.

Question 2 (b) (i)

(i) State the unit of acceleration.

.... **[1]**

Most candidates were able to state the unit of acceleration correctly, but there were a few who wrote it down incorrectly, for instance m/s^{-2} or ms^{-1}.

Question 2 (b) (ii)

(ii) Explain how to use the graph to find the acceleration at any point during the fall.

No calculation is required.

....

....

....

....

.... **[3]**

Some candidates were able to correctly state that the gradient of a speed-time graph would give the acceleration, and a few went on to explain that this would be calculated by dividing the difference in speed by the difference in time.

There were three common misconceptions:

- Acceleration is not calculated as vertical speed ÷ time so no marks were given to candidates who gave that as their response.
- Several candidates incorrectly suggested that the area under to graph would be acceleration.
- Another group of candidates explained incorrectly that you could read the acceleration directly from the y-axis at any particular time.

Question 2 (c)

(b) **Fig. 1** shows how the skydiver's speed changed over time.

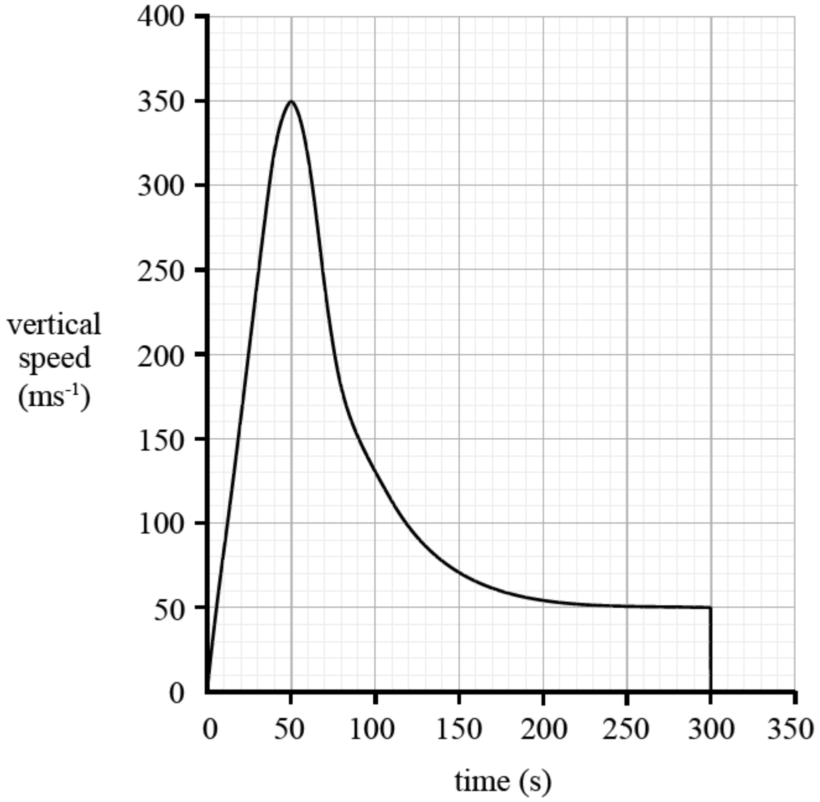

Fig. 1

(c) Use the graph in **Fig. 1** to estimate the height of the jump.

You may draw on the graph to show your method.

estimated height = ... m **[5]**

Some candidates realised that they had to find the area under the graph to calculate the distance travelled. This was carried out either by counting the large squares or by splitting the area into a number of geometric shapes and calculating the area of each. Some candidates attempted to use $s = t\left(\frac{u+v}{2}\right)$ for one pair of speeds. Some candidates tried to work out acceleration to use in $s = ut + ½at^2$, without realising that the acceleration was not constant for the whole time.

?	**Misconception**	Some candidates calculated the area of only part of the graph, as they thought that the jump began at, for example, 50s.

Question 3 (a)

3 **Fig. 2** shows an underfloor heating mat. The heating mat is used underneath floor tiles to heat rooms such as bathrooms.

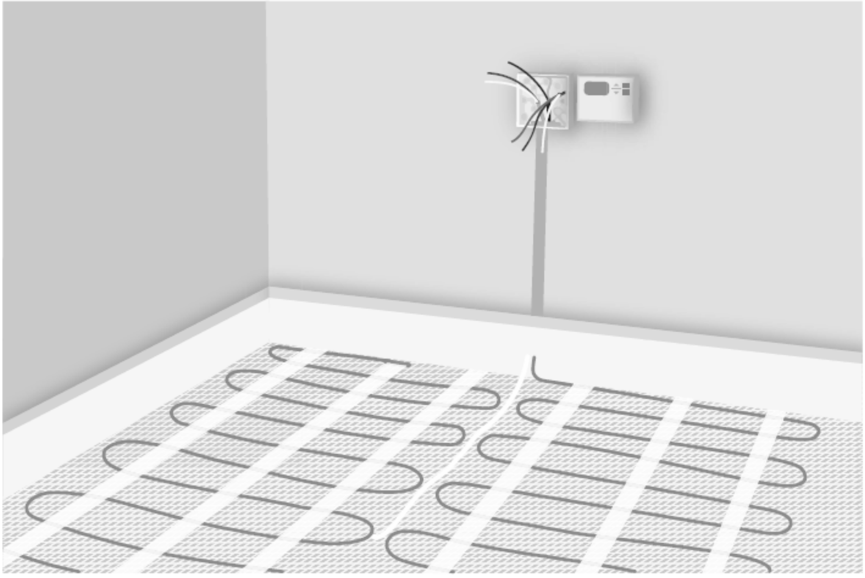

Fig. 2

The heating mat uses insulated, thick alloy wires. When there is an electric current in the wire there is a heating effect.

(a) Define electric current.

....

....

.... **[2]**

Most candidates were able to state that electric current is a flow of charged particles or electrons, but did not refer to the rate of flow or number of electrons passing in unit time.

Question 3 (b) (i)

(b) An underfloor heating mat with an operating resistance of 128 Ω is connected to the 240 V a.c. mains.

(i) Calculate the power input to the mat.

power = ... W **[2]**

This question was well answered, as most candidates were able to select the correct equation from the formula booklet and carry out the simple calculation.

Question 3 (b) (ii)

(ii) The mat is manufactured using wire with a cross-sectional area of 1.5 mm^2.

The resistivity of the wire when operating is 4.8×10^{-6} Ω m.

Calculate the length of wire needed to manufacture the mat.

length = ... m **[3]**

Many candidates correctly chose the equation $\rho = \frac{RA}{l}$ from the formula booklet, but some of them were unable to substitute the correct values into the equation. The resistance, *R*, was given at the beginning of part (b). Many candidates were unable to correctly convert area in mm^2 to m^2.

Question 3 (b) (iii)

(iii) The resistance of the underfloor heating mat is measured when it is turned off. The resistance is much less than expected.

Explain why the resistance of the wire is much less when turned off than when it is turned on.

....

....

....

....

.... **[2]**

This question was not well answered. Many candidates seemed to think that resistance was only present in the wire when current was flowing, rather than an intrinsic property of the wire. Few candidates used the term 'resistivity' in their responses, but some did explain why the resistivity of the wire would increase with temperature.

Question 3 (c)

(c) A different heating mat has a power output of 200 W.

The floor tiles have mass 15 kg.

The specific heat capacity of the tile material is 1150 J kg^{-1} K^{-1}.

Calculate the time taken for the tiles to warm up from 15 °C to 20 °C. Assume all the energy from the wires is absorbed by the tiles.

time taken = ... s **[4]**

Many candidates were able to choose the correct equation from the formula booklet and calculate the temperature difference correctly. The second part of the calculation was more difficult as some candidates were not sure which equation to use, or were unable to rearrange the correct equation correctly to find the time taken.

?	**Misconception**	When a temperature difference is used in a calculation, there is no need to convert the temperatures to the Kelvin scale. A temperature difference is the same in both scales.

Question 4 (a)

4 The atoms that make up a sample of metal are held together by forces.

Fig. 3 shows two forces, acting in opposite directions, on an atom due to the surrounding atoms.

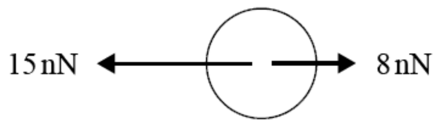

Fig. 3

(a) Determine the resultant force on the atom shown and state its direction.

force = ... nN **[1]**

direction = ... **[1]**

This question was relatively straightforward, so most candidates were able to answer this correctly. Some candidates put the direction as 'west' although there is no indication about where 'north' is.

Question 4 (b) (i)

(b) **Fig. 4** shows the resultant force on one atom due to a neighbouring atom when they are different distances apart.

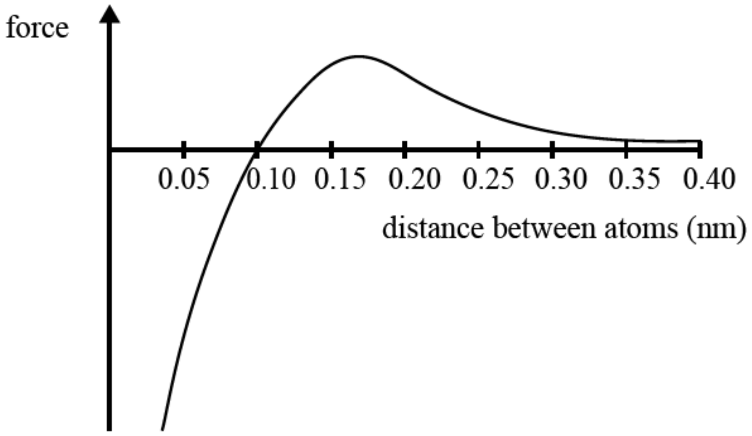

Fig. 4

(i) Use **Fig. 4** to determine the distance between the atoms when the force is zero.

distance = ... nm **[1]**

This was another relatively straightforward question where candidates should be able to read off the value on the distance axis when the force is zero.

Question 4 (b) (ii)

(ii) Explain what is meant by equilibrium separation.

....

....

....

....

.... **[2]**

Some candidates appeared to be unfamiliar with the term ‘equilibrium separation’ and tried to explain what they knew about equilibrium and a few of them were able to gain a mark for explaining that there would be a net force equal to zero at equilibrium. This question leads on from the previous one, so candidates should have realised that this may have had something to do with atomic spacing. Many candidates find it difficult to write clear explanations using correct scientific terminology.

Question 4 (c)

(c) When a metal sample is loaded lightly it will extend a small amount.

Which pair of statements describes what happens when the load is removed?

Tick (✓) **one** box.

The atoms attract and move apart. The metal shows plastic deformation.	☐
The atoms attract and move together. The metal shows elastic deformation.	☐
The atoms repel and move apart. The metal shows elastic deformation.	☐
The atoms repel and move together. The metal shows plastic deformation.	☐

[1]

There were many different responses to this question.

Question 4 (d)

(d) A wire is made from a metal.

The cross-sectional area is $2.4 \times 10^{-6}\,m^2$.

The wire is stretched with a force 5.5 kN.

The resulting strain in the wire is 0.015.

Calculate the Young's modulus for this metal.

Young's modulus = ... Pa **[4]**

It was good to see the majority of candidates able to perform this two-step calculation to calculate the Young's modulus. The most common error was to omit to convert the force in kN to N before doing the calculation.

	AfL	Candidates need to know the base SI units and the SI prefixes, so that they remember to convert correctly before carrying out any calculations.

Question 5 (a)

5 A car braking system works using pressure in a fluid as shown in **Fig. 5**.

When the driver presses the brake pedal, a force is applied to Piston **A**.

Piston **B** moves to press against the brake disk on the car's wheels and slows them down.

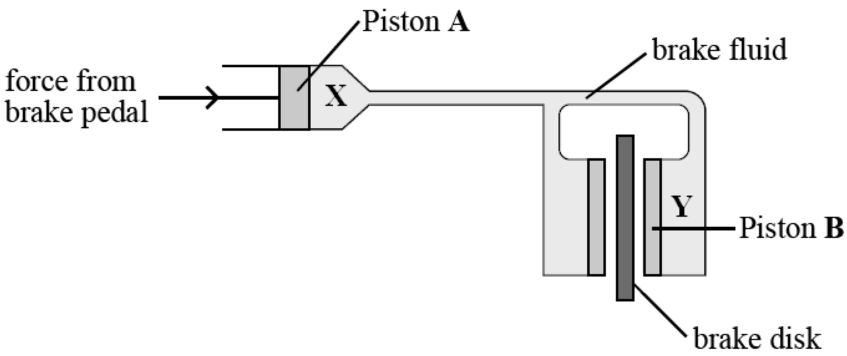

Fig. 5

(a) Circle the correct phrase from column **A and** the correct phrase from column **B** to complete the sentence.

	A		B
	less than		cannot be compressed.
The pressure at **X** is	more than	at **Y** because liquids	can be compressed.
	the same as		cannot be expanded.

[2]

Many candidates answered this question correctly.

Question 5 (b)

(b) The driver brakes gently and applies a force on Piston **A** of 450 N.

Piston **A** has a cross-sectional area of 2.0×10^{-4} m^2.

Calculate the pressure at **X**.

pressure at **X** = ... Pa **[2]**

Most candidates performed this simple calculation correctly.

Question 5 (c) (i)

(c) The driver brakes sharply so that the pressure at **Y** is 5 MPa.

(i) Convert 5 MPa to Pa.

.... Pa **[1]**

Most candidates showed that they could convert correctly, when asked directly to do so, but this is a task that often needs to be done within a calculation.

Question 5 (c) (ii)

(ii) The area of Piston **B** is $0.0018\,m^2$.

Calculate the force on Piston **B**.

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

Most candidates were able to perform this straightforward calculation correctly, but some did not rearrange the equation correctly.

Question 5 (d) (i)

(d) The brake fluid must have low viscosity.

(i) Describe what is meant by low viscosity.

....

.... **[1]**

Many candidates showed that they understand the term 'viscosity' but some candidates did not actually answer the question here, and just stated that viscosity was the resistance to shear forces without explicitly describing what 'low viscosity' meant. Again several candidates gave somewhat vague descriptions which lacked the correct scientific terminology.

Question 5 (d) (ii)

(ii) Calculate the kinematic viscosity of brake fluid with density $1050\,\text{kg}\,\text{m}^{-3}$ and dynamic viscosity of $0.25\,\text{N}\,\text{s}\,\text{m}^{-2}$.

Give the unit in SI base units.

Use the equation: $\text{kinematic viscosity} = \dfrac{\text{dynamic viscosity}}{\text{density}}$

kinematic viscosity = ... **[3]**

Most candidates were able to substitute the correct values into the given equation and calculate the correct value. Many candidates omitted the unit, but some did make an attempt to work out the unit. Some gave a dimensionally correct unit, but not directly in SI base units.

Question 6 (a)

6 An aeroplane engine uses a combustion chamber to power a gas turbine. A schematic diagram of a combustion chamber is shown in **Fig. 6**.

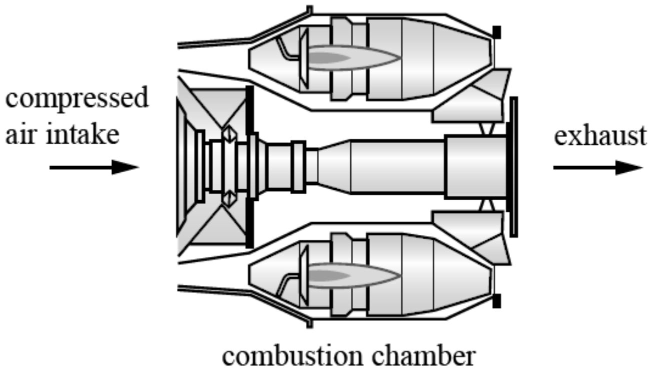

Fig. 6

Compressed air enters the combustion chamber at a temperature of 350 °C.

(a) Convert 350 °C to kelvin.

temperature = ... K **[1]**

Most candidates were able to convert temperature in ºC to Kelvin, but some mis-remembered the number to add, some subtracted and some divided.

Question 6 (b)

(b) The gas in the combustion chamber is heated from 350 °C to 1800 °C.

The volume of gas before heating is 1.2 m^3.

The pressure in the combustion chamber remains constant.

Calculate the volume of gas after heating.

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

The fact that the previous part of the question asked candidates to convert the temperature in ºC to Kelvin, should have indicated that this calculation required temperature to be in Kelvin. Many candidates correctly used the Charles' Law expression but then used the temperature values in ºC.

	AfL	The Gas Laws always require the temperature to be in Kelvin. A temperature difference (as used in calculations of specific heat capacity in Q4(d)) will be the same in both Kelvin and ºC. Temperature differences must not be converted to Kelvin.

Question 6 (c)

(c) The aircraft accelerates along the runway during take-off.

Energy is released from fuel at a rate of 160 MW.

The aircraft gains kinetic energy at a rate of 32 MW.

Calculate the overall efficiency of the engine.

efficiency = ... **[2]**

Many candidates were able to correctly calculate the efficiency and either gave the answer as a decimal or as a percentage. Some candidates did the division the wrong way round and ended up with an efficiency of 5 (or 500%).

?	**Misconception**	Efficiency can never be over one (or 100%) as energy is always wasted heating up the surrounding in any energy transfer.

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