CAMBRIDGE TECHNICALS

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Examiners' report

ENGINEERING

05822–05825, 05873

Unit 2 Summer 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.

Many candidates did well with the calculations in this paper, and many used the correct units and powers of ten. Candidates seemed better acquainted with the formula booklet. The more challenging topics in this paper included inductance and energy flow.

Candidates found it more difficult to write explanations clearly using the correct scientific terminology.

The graphical representation Question 2 (b) was answered particularly well.

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 • used appropriate scientific terminology correctly in explanations • interpreted diagrams correctly.	• identified correct equations to use for calculations • made power of ten errors when converting units • struggled to explain scientific concepts clearly.

Question 1 (a) (i)

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

(i) mass

.... **[1]**

Question 1 (a) (ii)

(ii) temperature

.... **[1]**

Question 1 (a) (iii)

(iii) amount of substance

.... **[1]**

Most candidates were able to state the correct units for mass, although a common error was to put grams instead of kilograms.

Many candidates were able to state the correct units for temperature with the common error to suggest degree Celsius instead of Kelvin.

Few candidates managed to correctly put moles as the unit for amount of substance. There were a wide variety of incorrect responses for this question.

Question 1 (b) (i)

(b) An ammeter consistently reads 0.1 A more than the true current flowing through it.

(i) Circle the correct term to complete the sentence.

Readings from this ammeter are ....

absolute inaccurate imprecise relative

[1]

Question 1 (b) (ii)

(ii) Which of these best describes the action that should be taken?

Tick **one** box.

Apply a –0.1 A absolute correction ☐

Apply a +0.1 A absolute correction ☐

Apply a –0.1 A relative correction ☐

Apply a +0.1 A relative correction ☐

[1]

Both parts of this question were answered quite well, even though some candidates incorrectly chose imprecise in part (i). Nearly all candidates chose one of the negative corrections in part (ii).

Question 1 (c)

(c) Define the term **uncertainty**.

....

....

.... **[2]**

This question was not well answered. Many candidates tried to describe precision or inaccuracy rather than uncertainty, and there were some candidates who did not try to use the term in an engineering context.

Question 2 (a) (i)

2 Car wheels need to be balanced to prevent dangerous vibration from happening at certain speeds.

Fig. 1 shows a wheel-balancing machine. The engineer attaches the car wheel to the axle. The machine spins the wheel and the computer displays information.

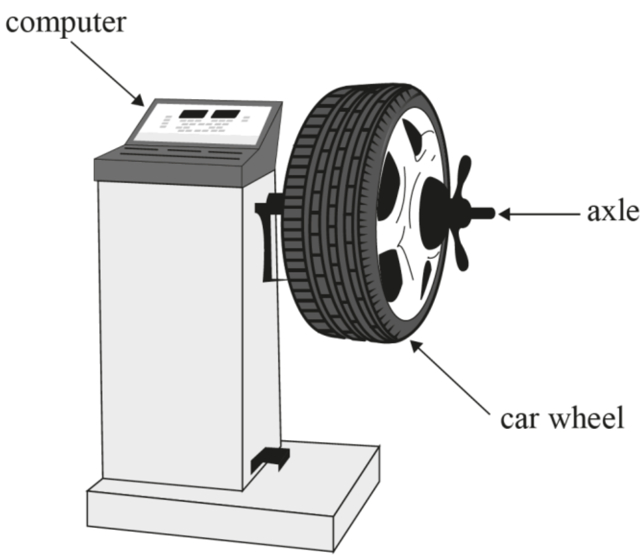


Fig. 1

(a) **(i)** **Fig. 2** shows the wheel stationary on the machine's axle.

The arrow labelled W represents the weight of the wheel.

Draw an arrow **on Fig. 2** to show the force applied to the wheel by the axle.

[2]

Many candidates correctly drew an up pointing arrow of approximate the same length as the weight arrow. Some candidates drew arrows to the right or left as the reaction force from the axle.

Question 2 (a) (ii)

Fig. 3 shows the wheel on the axle, viewed from the side.

Fig. 3

When the engineer releases the wheel, it rotates clockwise.

(ii) Explain why this shows the wheel is **not** in equilibrium.

....

....

.... **[2]**

Question 2 (a) (iii)

(iii) The engineer turns the wheel back to its original position and attaches a small weight to balance it.

Draw an X **on Fig. 3** to show approximately where the weight should be added.

[1]

Many candidates found it tricky to explain the concept of equilibrium relating to rotating motion, and many used vague terms about forces being the same. For the wheel to be in a state of equilibrium both the net moment and the net force acting on the wheel must be equal to zero. Few candidates referred to the term moment at all, but some were able to explain that one side of the wheel must have more weight than the other or that the centre of mass was not at the axle. As this question relates to a wheel balancing machine, no credit was given for referring to balanced forces.

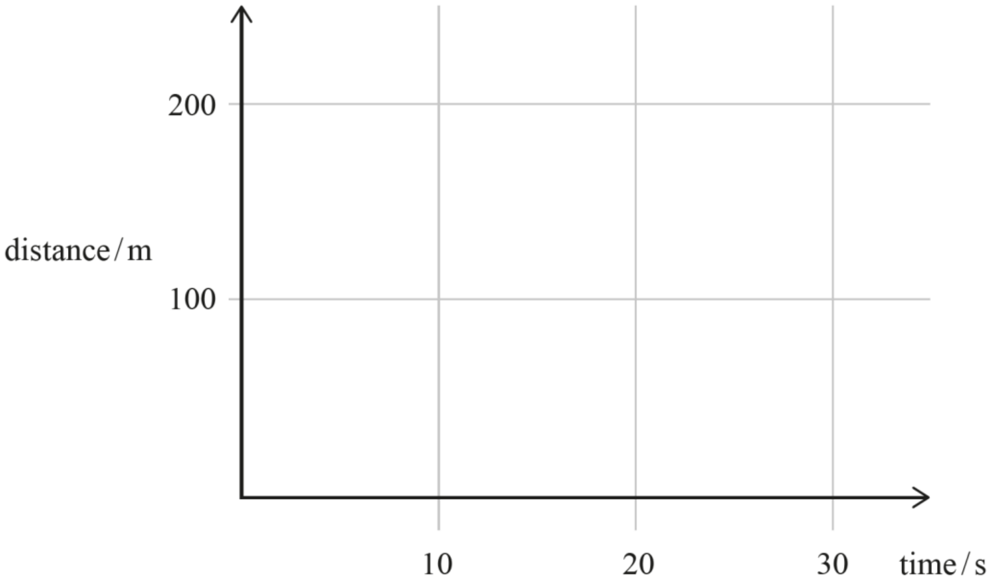
Many candidates correctly drew an X on the left side of the wheel to counter act the extra weight on the right-hand side causing the clockwise motion. Some candidates put the X at the bottom of the wheel.

Question 2 (b)

(b) The owner of the car drives it away from the garage.

They drive the car at $10\,m\,s^{-1}$ for 20 s and then stop for 10 s.

Show this journey on the distance–time axes below.



[3]

This question was answered well. Nearly all candidates drew the correct shaped graph, but a few miscalculated the distance covered at t = 20 s.

Question 2 (c)

(c) The mass of the car is 500 kg.

Calculate the kinetic energy of the car when it is travelling at $10\,m\,s^{-1}$.

Give the units for your answer.

kinetic energy = ... unit .... **[3]**

Many candidates used the correct equation to calculate kinetic energy and got the correct response. Some candidates forgot to square the velocity. Most candidates recalled correctly that the unit for energy is Joule or J.

Question 3 (a)

3 (a) Circle the correct words to complete the sentence.

Conventional current flows from ....

negative to earth   negative to positive   positive to negative

[1]

Candidates' responses to this question were approximately 50% choosing negative to earth and 50% correctly choosing positive to negative.

Misconception

The confusion about the direction of conventional current flow is due to the fact that in metals the mobile charge carriers are negatively charged electrons, which actually flow from negative to positive in a circuit. However conventional current always flows from positive to negative.

Question 3 (b)

(b) Explain how current flow in a semiconductor may differ from that in a metal.

....

....

....

.... **[2]**

Most candidates were not able to clearly explain that metals have a considerably higher conductivity than semi-conductors, therefore the current flowing in a metal would be much larger. Also, semi-conductors can have either positive or negative charge carriers while metals only have negatively charged electrons.

Question 3 (c) (i)

(c) **Fig. 4** shows a semiconductor diode.

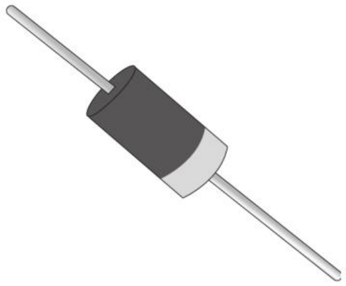


Fig. 4

The diode is connected in a circuit as shown in **Fig. 5**.

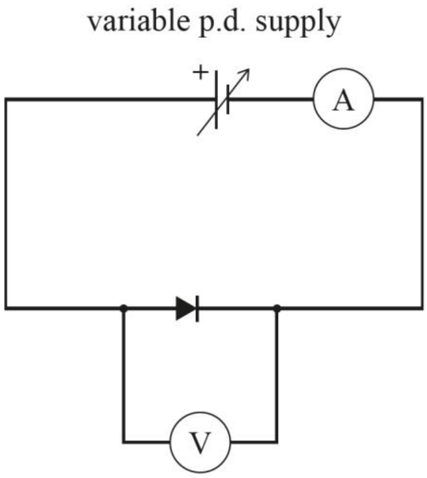


Fig. 5

The current through the diode is measured for different values of applied potential difference.

(i) Calculate the resistance of the diode when the potential difference across it is 3.0 V and the current through it is 0.15 A.

Give the units for your answer.

resistance = ... unit .... **[3]**

This question was well answered. Most candidates were able to calculate the resistance and nearly all candidates knew that the unit was Ohm.

Question 3 (d) (i)

(d) **Fig. 6** shows part of a circuit used to control a motor in a robot.

The motor acts like an inductor and the diode is connected in parallel with it to protect the rest of the circuit from voltage spikes.

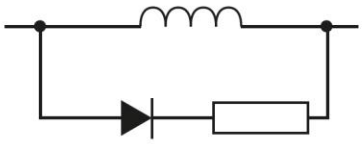


Fig. 6

The inductor coil is made up of 50 turns.

When the motor is running, the current is 150 mA and the magnetic flux is 1.2 m Wb.

(i) Calculate the self-inductance of the coil in milli-henry.

self-inductance = ... mH **[4]**

This question assessed understanding of a less familiar topic. Many candidates correctly selected the equation to calculate $L = \Phi N/I$ to find the value of L, but they then went on to use a second equation to find W_L the energy stored in the inductor. Many candidates who correctly calculated self-inductance L = 0.4 H then omitted to convert the response to mH. Many candidates also correctly converted both the flux and the current to SI units.

Question 3 (d) (ii)

(ii) When the motor is turned off, the energy in the magnetic field is dissipated in the resistor.

Show that the power dissipated in the resistor is 3 W if the energy stored in the field is 0.075 J and the time taken is 25 ms.

[2]

Many candidates correctly converted 25 ms to 25×10^{-3} s before using the equation P = W/t. This is to demonstrate that candidates need to show all the steps of their calculation, which should include writing out the full equation.

Question 4 (a) (i)

4 (a) (i) Define **stress**.

....

.... **[1]**

Question 4 (a) (ii)

(ii) State the unit for stress.

.... **[1]**

Most candidates correctly recalled both the definition and the unit for stress. Care is needed to make sure that the index is correct as several candidates wrote Nm^2 instead of N/m^2 or Nm^{-2}.

Question 4 (b)

(b) Give an example of a brittle material.

.... **[1]**

There were a number of incorrect suggestions of non-brittle materials. Common correct responses included glass, cast iron or ceramic.

Question 4 (c) (i)

(c) **Fig. 7** shows a force–extension graph for a brittle material, labelled **B**.

Fig. 7

(i) Draw, on the axes in **Fig. 7**, a force–extension graph for a ductile material.

Label this **D**.

[2]

Question 4 (c) (ii)

(ii) Draw, on the axes in **Fig. 7**, a force–extension graph for a non-brittle polymer.

Label this **P**.

[2]

This question was not well answered. Candidates should be able to sketch the typical shape of force-extension graph for the main classes of materials.

A ductile material starts off with a relatively steep linear section of elastic deformation with a much larger region of plastic deformation with large extension for small increase of force.

A non-brittle polymer should start off with a relatively steep section with decreasing gradient, followed by an increasing gradient.

Question 4 (d)

(d) A small force is applied to a brittle material.

The material does not break.

Describe what happens to the atoms in the brittle material when this force is removed.

....

....

.... **[2]**

Many candidates correctly stated that the atoms would return or go back but omitted to state that they would return to their equilibrium position. Some candidates missed the point of this question and just said that the atoms would remain in place.

Question 4 (e)

(e) Explain the difference between elastic and plastic deformation of a material.

....

....

....

.... **[2]**

Most candidates gave a macroscopic explanation for this question stating that elastic deformation was reversible whereas plastic deformation was permanent but did not categorically state that this was after the force was removed. Some candidates gave some good microscopic explanations about plastic deformation involving planes of atoms sliding over one another.

Question 5 (a)

5 (a) Which of the following is **not** a fluid?

Tick **one** box.

Gas ☐

Liquid ☐

Solid ☐

[1]

Most candidates were able to correctly state that solids are not fluids.

Question 5 (b) (i)

(b) For safety, divers take a hollow plastic marker buoy to show their position.

(i) **Fig. 8** shows a diver holding their marker buoy underwater.

Fig. 9 is a close-up of the marker buoy.

Fig. 8

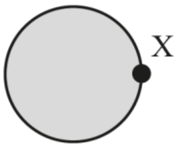


Fig. 9

The marker buoy in **Fig. 9** is underwater.

Draw an arrow **on Fig. 9** to show the direction that water pressure acts on the marker buoy at position X.

[2]

Many candidates got this question correct. A common error was to put an upwards pointing arrow at X.

Question 5 (b) (ii)

(ii) The diver wears a device on their wrist that measures gauge pressure.

Which of the following is the correct way to convert the reading to absolute pressure?

Tick **one** box.

absolute pressure = atmospheric pressure – gauge pressure ☐

absolute pressure = gauge pressure + atmospheric pressure ☐

absolute pressure = gauge pressure – atmospheric pressure ☐

[1]

Most candidates got this question correct.

Question 5 (b) (iii)

(iii) The top of the diver's marker buoy is 2.0 m from the surface.

Calculate the pressure on the top of the marker buoy due to the column of water above.

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

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

Type your commentary here

Question 5 (b) (iv)

(iv) Circle the correct words to complete the sentence.

The pressure on the bottom of the marker buoy is .... on the top.

less than more than the same as

[1]

There were many different responses to this question, with probably about half the candidates getting it correct.

Question 5 (c)

(c) Describe the upthrust force on an immersed object.

....

....

.... **[2]**

Candidates did not answer this question particularly well. In order to describe a force, they should include a direction and a size. Many candidates simply copied down an equation from the formula booklet here, and this is not a description of a force.

Question 6 (a) (i)

6 **Fig. 10** shows a type of household central heating boiler that includes a Stirling engine. This type of boiler heats water and also generates electricity.

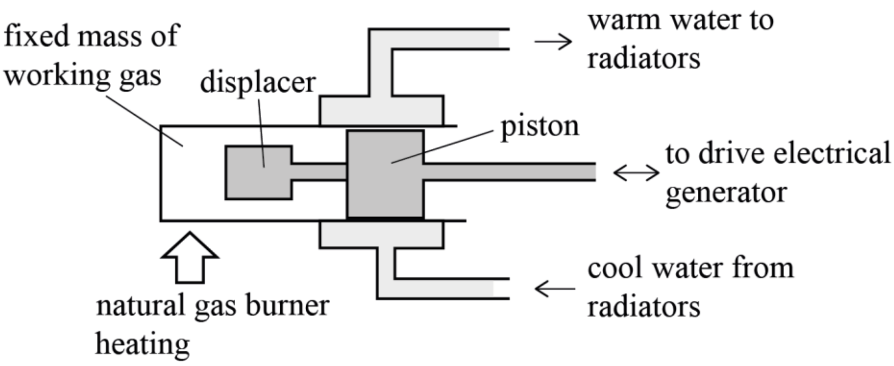


Fig. 10

- The Stirling engine contains a fixed mass of a working gas (usually helium).
- The boiler burns natural gas to heat the working gas in the Stirling engine.
- The piston of the Stirling engine drives an electrical generator.
- The displacer moves the working gas from left to right.
- Cool water returning from the radiators is heated as it passes over the right-hand side of the Stirling engine before flowing back to the radiators again.

(a) **(i)** State how energy is transferred **to** the working gas.

....

.... **[1]**

Question 6 (a) (ii)

(ii) State how energy is transferred **away from** the working gas.

Give **two** answers.

1 ....

2 ....
[2]

This question was not well answered. Candidates should be able to identify how the energy is transferred both to and away from the working gas. Many candidates did realise that the working gas was being heated by the burning of natural gas, but they found the second part more challenging. Energy is being taken away from the working gas both thermally to the water and mechanically to the piston. The displacer is there to stir the gas and is not an energy output.

Question 6 (a) (iii)

(iii) The energy entering the working gas in one cycle of the engine is equal to the energy leaving the working gas.

Show that the change in internal energy of the working gas is zero.

Use information in section 6.5.1 of the Formula Booklet to help you.

[2]

Candidates needed to recognise that the non-flow energy equation was the relevant one. In order to show that a statement is true, they need to start from the initial statement and try to derive the second one and show all lines of their working. Just stating that internal energy = zero is incorrect, it is change in internal energy which is zero.

Question 6 (b) (i)

(b) A different Stirling engine contains 1.2 g of helium gas at 453 K.

(i) Calculate the pressure of the gas when its volume is 0.006 m^3.

The specific gas constant for helium is 2.08 $J\,g^{-1}\,K^{-1}$.

pressure = ... Pa **[3]**

Some candidates did correctly identify the ideal gas equation to use and correctly substituted values in to find the pressure. The value of R is given in $J\,g^{-1}\,K^{-1}$ so there is no need to convert the mass of gas from 1.2 g to 0.0012 kg in this calculation.

Question 6 (b) (ii)

(ii) What is 453 K in °C?

.... **[1]**

Although many candidates were able to convert the temperature in Kelvin to temperature in degrees C, many were unable to recall the value of absolute zero, and some added it rather than subtracted it.

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