CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

Unit 2 January 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.

Unit 2 series overview

Unit 2 paper appeared to be accessible with the majority candidates attempting all questions. There is some improvement in candidates showing their working in calculation questions, but some candidates struggle to use scientific terminology in written answers. There is evidence that some candidates are learning by rote rather than developing a deeper understanding of scientific concepts. The formula booklet is intended as an aide memoir, and candidates should still be learning underlying scientific principles, rather than just copying out equation.

Candidates who performed well, tended to:	*Candidates who did less well tended to:*
• use appropriate scientific terminology • show clear working in all calculations • remember to convert units into standard units before carrying out any calculation.	• find it difficult to apply what they had learnt to unfamiliar contexts • make careless mistakes in calculations • use incorrect terminology.

AfL

Where units are given on an answer line, candidates should be able to work backwards from the units to determine how to calculate the answer. For example, in question 3(a)(ii) the units on the answer line are kW h. This means that power in kW is multiplied by time in hours.

Question 1(a)

1 (a) Complete the table below showing the SI units for some physical quantities. The first row has been completed as an example.

SI Unit	Symbol	Physical Quantity
metre	m	length
Ampere		
	K	
	cd	

[3]

This question required candidates to recall some of the base SI units. Most candidates got the first two lines correct. Some candidates put the symbol for current (I) rather than the symbol for Ampere (A) and/or gave the physical quantity as 'Amps' rather than current. A few candidates referred to the physical quantity 'heat' instead of 'temperature' for K. Candidates found the last row difficult. Several did manage to put candela as the unit and there was some confusion between luminosity and luminous intensity.

Question 1(b)

(b) Fig. 1 shows an enlarged view of a Vernier caliper scale measuring the diameter of a ball bearing. The scale reads in mm.

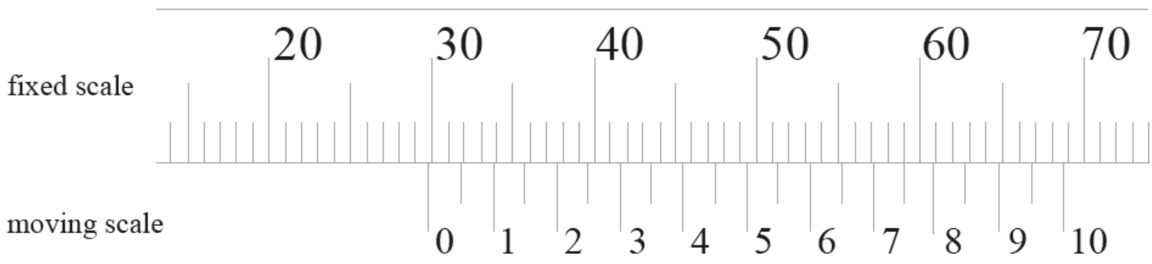

Fig. 1

State the diameter of the ball bearing.

Diameter = ... mm **[1]**

Some candidates could read the Vernier scale correctly; others could not. Answers had to be correct to 4 significant figures so values such as 29.7 or 29.8 did not gain the mark. Common incorrect responses included 39 and 59.

Question 1(c)(i)

(c) Several measurements of the depth of a groove are recorded as shown below.

Measurement no.	1	2	3	4	5
Depth (mm)	12.11	11.95	12.03	11.99	11.97

(i) If the true value for depth is 12.00 mm, calculate the percentage error of measurement number 3.

Percentage error = ………………………… **[2]**

Many candidates correctly calculated the percentage error of 0.25%. A common error was to multiply the absolute error of 0.03 by 100 to express it as a percentage. This did not gain any marks.

(ii) Show that the mean value is 12.01 mm.

[1]

Question 1(c)(ii)

Most candidates correctly wrote down the calculation performed to find the mean of the 5 values.

Question 1(c)(iii)

(iii) Calculate the standard deviation of the measurements.

Give your answer to 4 significant figures.

Standard deviation = …………………………**[3]**

Many candidates were able to write down the correct equation to use to find standard deviation and some were able to interpret that equation and find the sum of the squares correctly. A common error was then to forget to take the square root of the value and this meant that only 2 marks were awarded. Some candidates only gave the final value to 3 significant figures, perhaps incorrectly thinking that the zero following the decimal point is significant. Some candidates used 12.00 as the mean value instead of 12.01. Some candidates did not show their working, as they used a statistical function on a calculator. Provided the answer was correct to 4 significant figures, full credit was given for this method. In some cases, however, where there was an incorrect final answer, intermediate marks could not be awarded as there was no evidence of the method.

Question 2(a)(i)

2 **(a)** Fig. 2 shows a parked vehicle of mass 1000 kg on a slope at a height of 7 m above a surface.

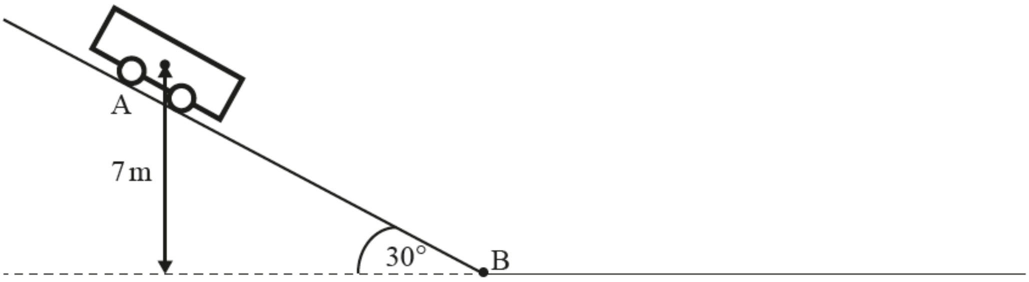

Fig. 2

(i) Calculate the gravitational potential energy of the vehicle.

Potential energy = ...J **[1]**

Many candidates used the correct equation to calculate potential energy of the vehicle.

Question 2(a)(ii)

(ii) The handbrake is released, and the vehicle travels from point A to point B.

Ignore the effect of friction on the slope.

Show that the velocity of the vehicle at point B is about $12\,\mathrm{m\,s^{-1}}$.

Velocity = ... $\mathrm{m\,s^{-1}}$ **[2]**

There are two valid methods for finding the velocity of the vehicle. The most straightforward method is to equate the potential energy calculated in part (i) to the kinetic energy of the vehicle at the bottom of the slope, and then re-arranging to find the velocity of 11.7 $\mathrm{ms^{-1}}$. More candidates attempted to use the SUVAT equations. This method requires candidates to resolve the acceleration of gravity in the direction of motion, and to find the length of the slope using trigonometry, so was more prone to errors. A common error in this question was for a candidate to use the value v = 12 $\mathrm{ms^{-1}}$, and then complete some calculations to 12 $\mathrm{ms^{-1}}$ again. This gained no marks.

Question 2(a)(iii)

(iii) After point B the vehicle continues moving along the horizontal surface.

The average friction force acting on the vehicle is 2.94 kN.

Calculate the time it takes for the vehicle to stop.

Time to stop = ... s **[3]**

Many candidates correctly found the acceleration (or deceleration) of the vehicle, and then using an initial velocity of 12 ms^{-1}, calculated the time by dividing the change in velocity by acceleration. A common error was to try to include the value for potential energy in the calculation.

Question 2(b)(i)

(b) Fig. 3 shows how the position of an object moving along a horizontal plane varies with time.

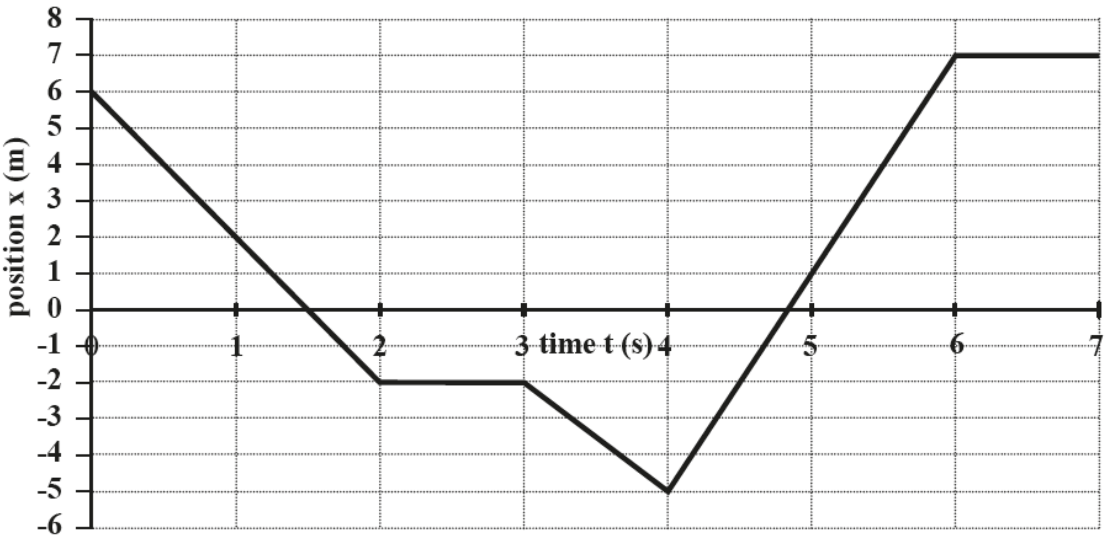

Fig. 3

Use Fig. 3 to determine the following;

(i) the displacement between $t = 0$ s and $t = 7$ s,

Displacement = ... m **[1]**

Question 2(b)(ii)

(ii) the total distance travelled between $t = 0$ s and $t = 7$ s,

Distance travelled = ... m **[1]**

These two questions assessed whether candidates understood the difference between displacement and distance and most candidates got them both right. Some made an arithmetic error in part (ii). A few candidates tried to work out the area under the graph, and a few put the same value down for both parts.

Question 2(b)(iii)

(iii) the average velocity between $t = 4$ s and $t = 7$ s.

Average velocity = ... m s^{-1} **[2]**

Many candidates correctly calculated average velocity over the 3 second period. Some found the gradient of the line from t = 4s to t = 6s; and could gain one mark provided they correctly showed that the total distance covered was 12 m. Candidates giving a wrong answer with no working gained no marks.

AfL

Encourage candidates to show working in calculations.

Question 3 (a)(i)

3 **(a)** A power tool is connected to a battery pack. The tool operates with a normal power output of 1 kW. The efficiency of the system is 85%.

(i) Calculate, in watts, the input power required to operate the power tool.

Input power = ………………………………W **[1]**

Many candidates selected the efficiency equation from the formula booklet, but did not use it correctly. In this question the output power is given as 1 kW or 1000 W, and this should be divided by the efficiency of 85%. A common error was to multiply the output power by 85%.

Question 3(a)(ii)

(ii) The tool operates for a duration of 30 minutes.

Calculate the energy input in kWh.

E = ………………………………kWh **[2]**

Many candidates multiplied the power calculated in part (i) by a time to give energy, but this only gained one mark unless correct units were used in the calculation. To give a value in kWh, the power needs to be in kW and the time needs to be in hours. Common errors included using time in minutes, or seconds.

AfL

Encourage candidates to look at the units on the answer line, so that they can work out which units to use in the calculation.

Question 3(b)

(b) Fig 4 shows current-potential difference curves (***X***, ***Y*** and ***Z***) for three different components.

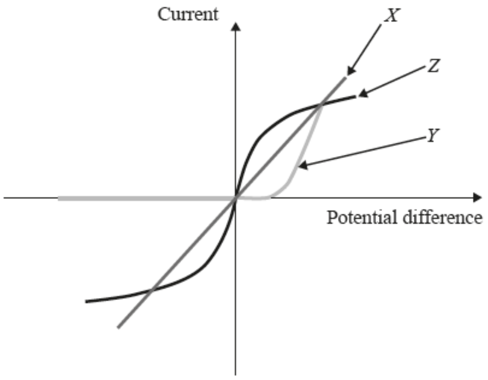

Fig. 4

Complete the table below to match the curve (***X***, ***Y*** and ***Z***)) to the component.

Component	**Curve (*X*, *Y* or *Z*)**
Resistor at constant temperature	
Filament lamp	
Diode	

[2]

Most candidates were able to correctly identify the straight line as the curve for the resistor at constant temperature, and therefore gained one mark. Some candidates also correctly distinguished between the filament lamp and diode.

Question 3(c)(i)

(c) Fig. 5 shows a simple RL circuit.

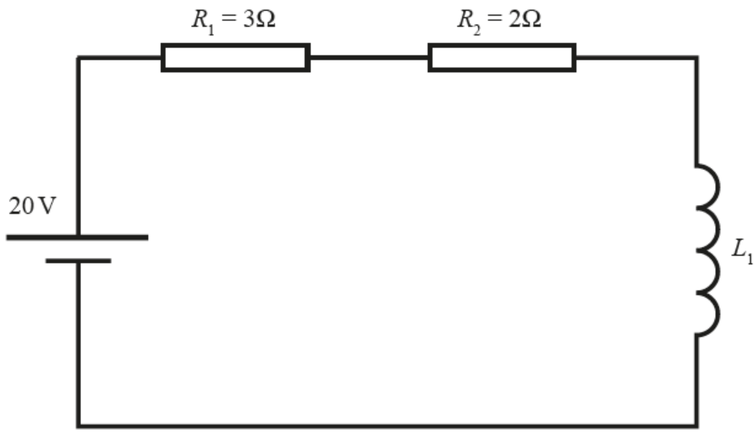

Fig. 5

(i) Calculate the equivalent resistance R_{eq} from the two resistors R_1 and R_2.

R_{eq} = ... Ω **[1]**

Nearly all the candidates correctly added the two resistance values together.

Question 3(c)(ii)

(ii) The power source provides a voltage of 20 V.

Calculate the current circulating through the coil.

Current = ... A **[1]**

Most candidates correctly rearranged the equation to calculate current by dividing 20 V by the resistance value from part (i).

Question 3(c)(iii)

(iii) The coil is made up of 100 turns and produces a magnetic flux of 10 mWb for this current.

Calculate the self-inductance of the coil. Include a unit in your answer.

Self-inductance = ... **[3]**

Many candidates selected the correct equation from page 15 of the formula booklet and gained the first marking point. Some candidates correctly substituted the values for magnetic flux, number of turns and current and were able to achieve the second mark. In order to gain full marks a consistent unit was also needed. If a candidate left the flux as 10 mWb then the inductance would have been in mH, but if the flux was converted to 10×10^{-3} Wb, then the correct unit would be H. Another common error here was for candidates to correctly calculate the self inductance, but then go on to use that value to calculate the energy stored in the inductor.

Question 4(a)

4 (a) Explain the difference between **resilience** and **toughness** of materials.

....

....

.... **[2]**

This question was not well answered. Candidates need to use the correct terminology to describe material properties. Few candidates appreciated that both resilience and toughness are measures of the amount of energy stored in materials. Some did state that resilience was to do with a material's ability to spring back into shape but did not refer to elastic deformation.

Misconception

Toughness is related to impact strength but is not a measure of the amount of force or stress a material can withstand. It is a measure of its ability to absorb energy on impact.

Question 4(b)

(b) Explain the difference between the **malleability** and **ductility** of materials.

....

....

.... **[2]**

This question was answered better than part (a). Many candidates described ductility as a material's ability to be drawn into wires. A common answer was to state that malleability was a material's ability to be shaped, without referring to compression.

Question 4(c)(i)

(c) A cylindrical rod of diameter 26 mm is subjected to a tensile load of 18 kN.

The original length of the rod is 150 mm and the extension is measured as 24 μm.

(i) Calculate the Young's modulus of the material. Include a unit in your answer.

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

Many candidates made a good attempt to calculate Young's modulus by first calculating stress and strain. Several unit conversions were necessary here. Other common errors included using diameter instead of radius to find area, or just using diameter or radius as the area of the wire.

AfL

1 MPa = 1 MN m^{-2} = 1 N mm^{-2}.

So, if the area is calculated in mm^2 and the force is in N, the stress will be in MPa.

Question 4(c)(ii)

(ii) The yield strength of the material is 350 MPa.

Calculate the maximum elongation of the rod before plastic deformation occurs.

Maximum elongation = ... mm **[2]**

This question was not well answered. Many candidates tried to use Young's modulus equation again but substituted the yield strength of 350 MPa as the value for Young's modulus, and then used 18 kN as the force. Some candidates did correctly calculate strain, but then did not multiply by original length to give extension.

Question 5(a)

5 (a) A gas and a liquid are both fluids, but they behave differently under applied pressure.

Explain this difference in behaviour.

[2]

Some candidates correctly stated that gases can be compressed whereas liquids cannot. Few candidates went on to say that this meant that a volume of a gas will decrease under pressure. Responses relating to microscopic behaviour were not expected here.

Question 5(b)

(b) Fig. 6 shows the cross section of two pipes.

Sketch diagrams on Fig. 6 to show laminar and turbulent flow through the pipes.

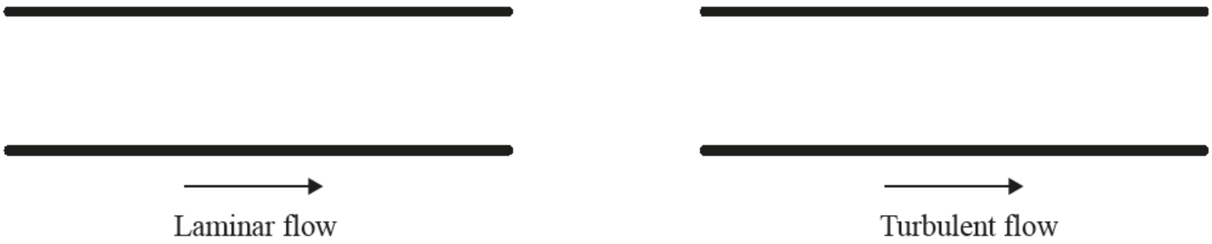

Fig. 6

[2]

Many candidates drew acceptable diagrams to represent the different types of flow. Common errors included omitting direction arrows or drawing curved but parallel lines to represent turbulent flow.

Question 5(c)(i)

(c) Fig. 7 shows a cuboid of mass 2.0 kg.

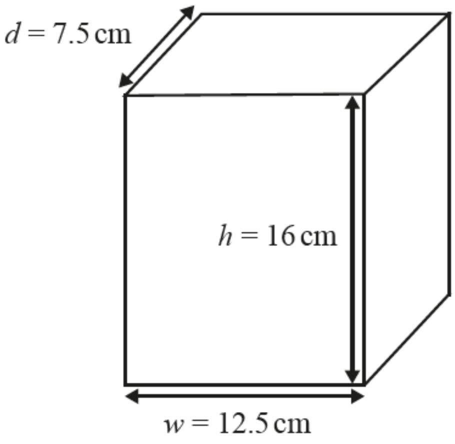

Fig. 7

(i) Calculate the density of the cuboid.

Density = ... kg m^{-3} **[2]**

Most candidates could calculate density. A common error was to calculate volume in cm^3, and not convert to m^3 before finding density.

Question 5(c)(ii)

(ii) The cuboid is dropped into water which has a density of 1000 kg m^{-3}.

State whether the cuboid floats or sinks. Justify your answer.

....

.... **[1]**

Few candidates had any problem with this question. Where a candidate had incorrectly calculated the density of the cuboid to be less than 1000 kg m^{-3}, they were credited if they stated why the cuboid would float.

Question 5(c)(iii)

(iii) Calculate the upthrust force acting on the cuboid.

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

Most candidates used the correct equation to calculate upthrust force. Some substituted the density of the cuboid calculated in part (i) instead of the volume of the cuboid.

Question 6(a)(i)

6 **(a)** Fig. 8 shows a tank filled with helium, at an initial temperature of 70 °C.

The initial internal energy of the system is 1200 J.

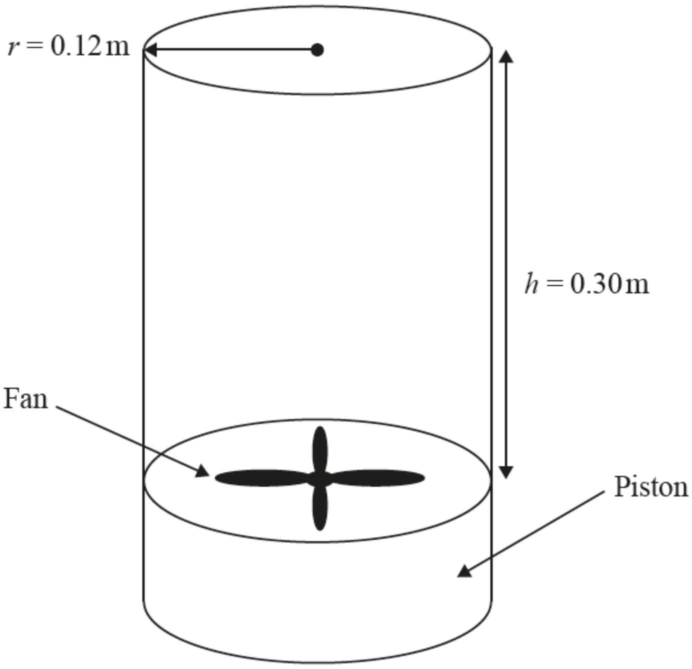

Fig. 8

(i) The fan at the bottom of the cylinder does work on the helium at a rate of 1.5 W for 5 minutes.

The final internal energy of the helium is measured at 900 J.

Calculate the energy lost by the helium.

Energy lost = ... J **[2]**

Only a few candidates gained both marks for this question. Some candidates tried to calculate the energy supplied by the fan by multiplying 1.5 W by the time; some remembering to convert 5 minutes to 30 seconds, and some not. There was sometimes confusion about the direction of the energy flow, so some candidates used the wrong signs in the sum. The most common error here was to omit any energy supplied by the fan and just do a simple subtraction of 1200 J – 900 J.

Question 6(a)(ii)

(ii) Calculate the new temperature of the helium in the cylinder.

Density of helium = 0.16 kg m^{-3}.

Specific heat capacity of helium = 5200 J kg^{-1} K^{-1}.

Temperature = ... °C **[4]**

Many candidates found this question difficult but those who correctly calculated the volume and hence mass of the helium were credited with 2 marks. Some candidate did then manage to calculate the temperature difference by substituting that mass into the equation for sensible heat. Only a few candidates completed the final step of subtracting the temperature difference from the initial temperature of 70°C.

Question 6(a)(iii)

(iii) The fan stops and the piston on which it is attached moves upwards a distance of 0.18 m.

If the temperature of the helium remains constant, calculate the percentage increase in pressure inside the cylinder.

Percentage increase in pressure = ... **% [3]**

This was another challenging question for most candidates. Some candidates gained credit for finding the new volume of the helium, but in order to gain full marks they needed to find a ratio. The ratio of volume is equal to the inverse of the ratio of pressure because P V is a constant.

Question 6(b)

(b) A bedding manufacturer is selecting a new fabric for use in electric blankets.

Fabric	**Specific Heat Capacity (J kg^{-1} K^{-1})**
A	1700
B	900

State and explain which is the most suitable fabric, assuming the blankets produced from both fabrics have the same mass.

....

....

....

....

.... **[2]**

Most candidates gained both marks here by justifying their choice of material with an explanation about the rate at which it heats up or cools down. A common error was to suggest that a low specific heat capacity meant that the blanket would not combust.

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