OCR
Oxford Cambridge and RSA

Friday 10 January 2020 – Morning

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873 Unit 2: Science for engineering

Time allowed: 1 hour 30 minutes
C302/2001

C302I12001

You must have:
- the Formula Booklet for Level 3 Cambridge Technical in Engineering (inside this document)
- a ruler (cm/mm)
- a protractor
- a scientific calculator

Please write clearly in black ink.

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working.
- Give your final answers to a degree of accuracy that is appropriate to the context.
- The acceleration due to gravity is denoted by g m s^{-2}. Use g = 9.8 unless the question says something different.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/9
2	/10
3	/11
4	/10
5	/14
6	/6
Total	**/60**

Answer **all** the questions.

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.

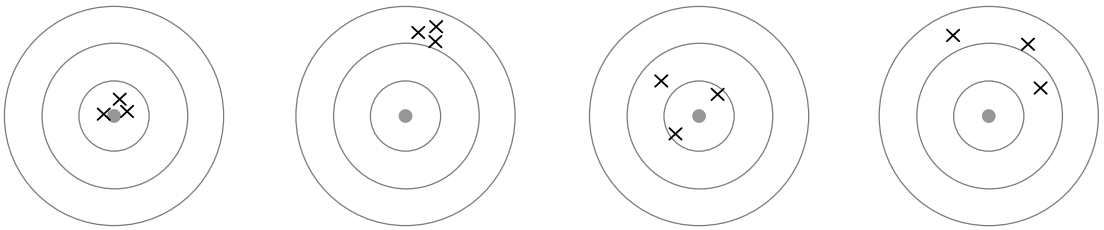
Derived quantity	**SI base units**
velocity	$kg\ m^2\ s^{-3}$
acceleration	$m\ s^{-2}$
force	$kg\ m\ s^{-2}$
power	$m\ s^{-1}$

[2]

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

Tick (✓) **one** box.

Key
- ● true value
- × measured value



[1]

(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]**

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

.....

.....

.....

..... **[2]**

(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]**

2 **(a)** Define the Newton.

.....

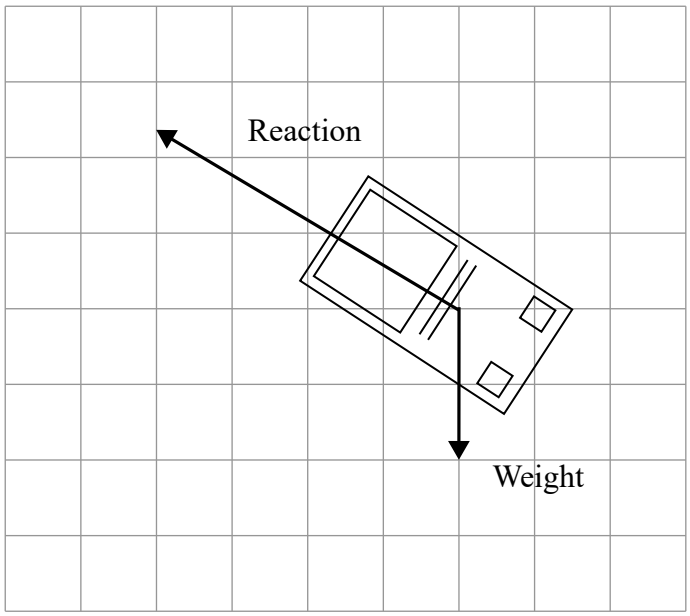
.....

..... **[2]**

(b) A bus is driven around a banked test track as shown in Fig. 1.

Fig. 1

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]**

(ii) Calculate the mass of the bus.

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

(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]**

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

Define the term 'centre of gravity'.

.....

.....

..... **[2]**

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

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

State the name of the SI unit for charge.

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

(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.

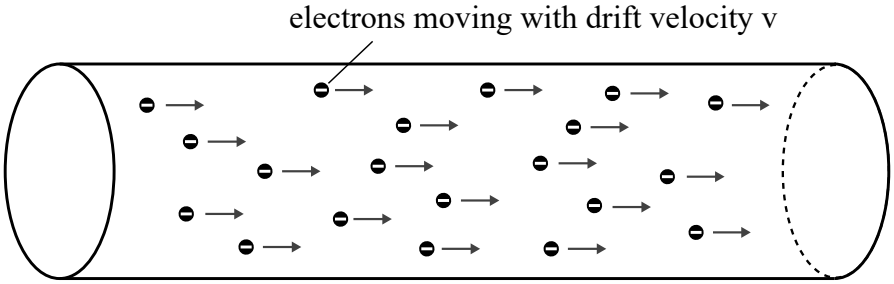


Fig. 3

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]**

(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]

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

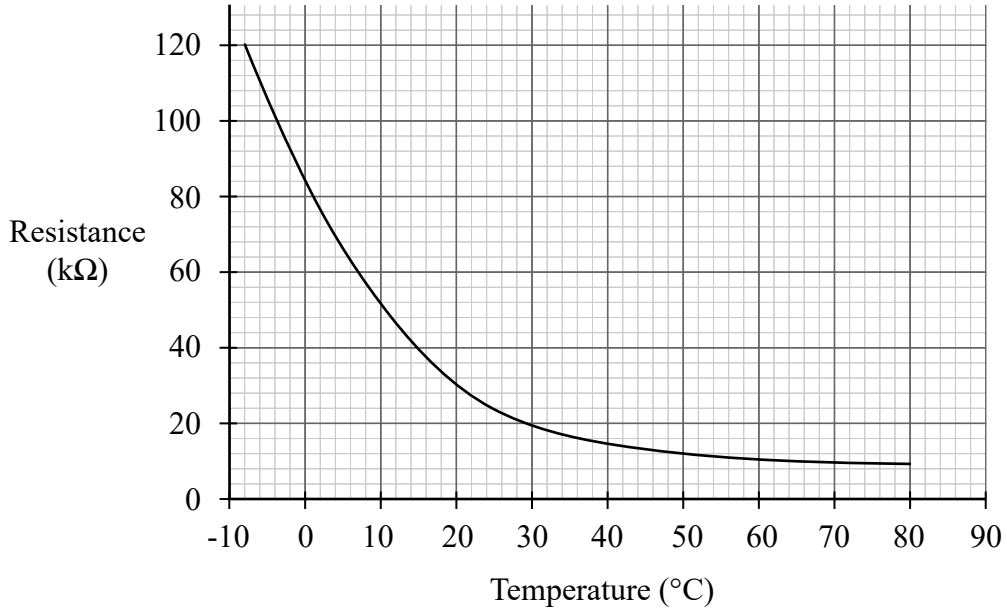


Fig. 4

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

resistance = ... kΩ **[1]**

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

change in resistance = ... kΩ **[2]**

(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]**

Turn over for the next question

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

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

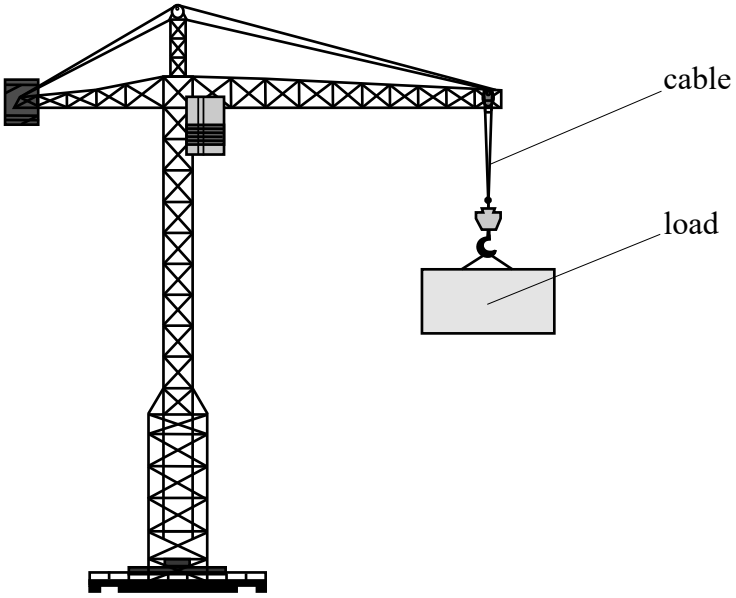


Fig. 5

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]

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

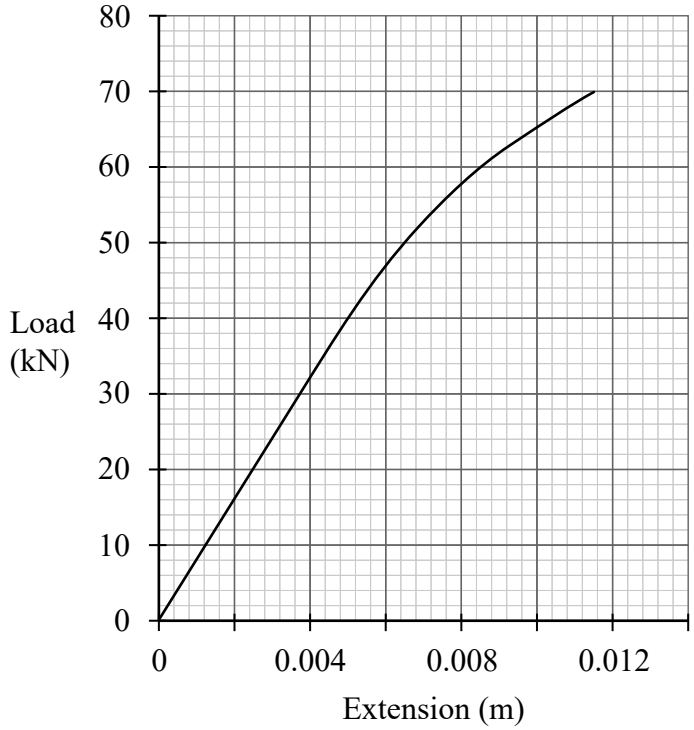


Fig. 6

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

Use information from Fig. 6.

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

(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]**

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

Give the units for your answer.

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

Turn over for the next question

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

1 .....

2 .....
[2]

(b) State Archimedes' principle.

.....

.....

.....

..... **[2]**

(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]**

(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]**

(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]**

(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]**

6 **(a)** Complete the sentence below.

Absolute zero is the temperature at which all substances …

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

(b) Convert 18 °C to kelvin.

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

(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]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 1(c)(ii) or 2(a).

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....