OCR
Oxford Cambridge and RSA

Tuesday 23 May 2023 – Morning

Level 3 Cambridge Technical in Engineering

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

Time allowed: 1 hour 30 minutes
C302/2306

C302I12306

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

0 5 8 2 2 – 0 2

Please write clearly in black ink. **Do not write in the barcodes.**

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. Marks might be given for using a correct method, even if your answer is wrong.
- 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}. When a numerical value is needed use g = 9.8 unless a different value is specified in the question.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **16** pages.

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

1 **(a)** **(i)** State the SI base unit for the following:

Amount of substance .....

Luminous intensity .....

[2]

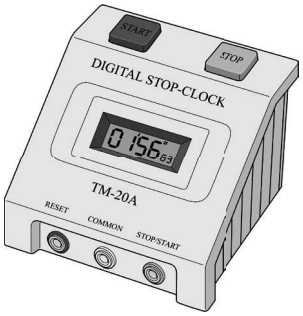
(ii) Draw lines to match the SI prefixes with their values.

micro (μ) •	• 10^{-9}
milli (m) •	• 10^{-6}
nano (n) •	• 10^{-3}

[2]

(b) The image below shows a digital timer.

The digital timer can be started and stopped either by hand (using the buttons) or electronically (using the connections on the front).



The timer reads to the nearest 1/100th of a second (0.01).

(i) An engineer measures and records the time for a prototype robot to climb a short ramp.

time = (2.64 ± 0.01) s

Calculate the percentage uncertainty (error) for this measurement.

percentage uncertainty = ... % **[2]**

(ii) The engineer used the buttons to start and stop the timer.

Explain why the engineer was wrong to use ±0.01 as the uncertainty of the measurement.

.....

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

(iii) The engineer then sets up some light gates to control the timer electronically.

The engineer measures the time for the robot to climb the ramp four more times.

Trial	**Time (s)**
1	2.64
2	2.72
3	2.28
4	2.86
5	2.55

Calculate the average (mean) time.

average time = ... s **[1]**

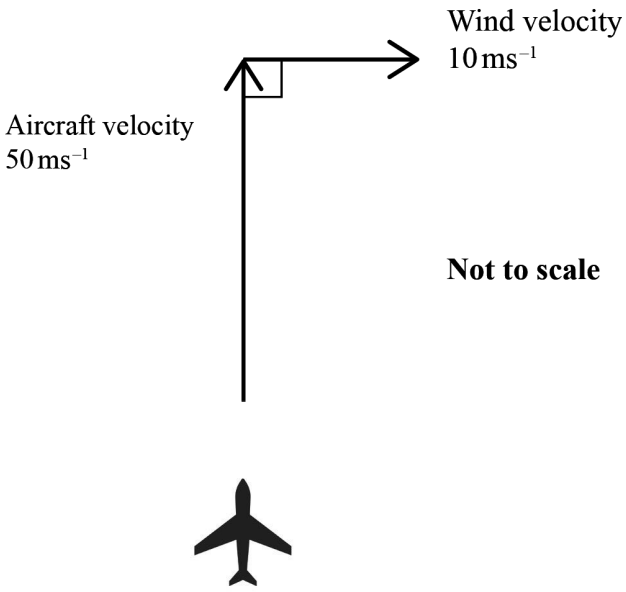
(iv) Explain how the results show that the precision of the average time is still not ±0.01.

.....

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

2 **(a)** **Fig. 1** shows an aircraft flying in a crosswind.

Fig. 1



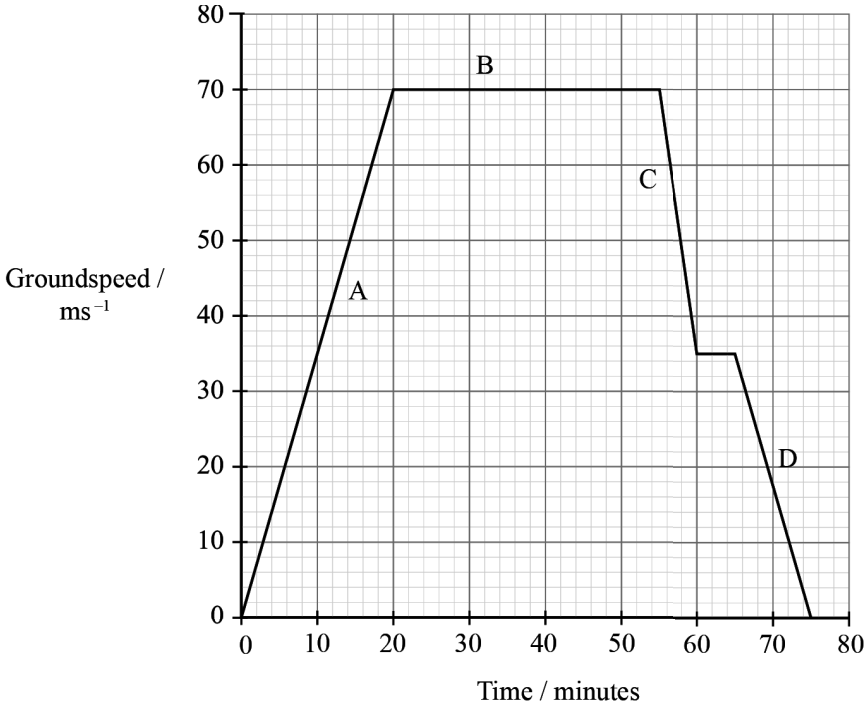
(i) Draw an arrow on **Fig. 1** showing the resultant velocity of the aircraft over the ground.

[1]

(ii) Calculate the magnitude of the resultant velocity (the 'groundspeed').

groundspeed = ... ms^{-1} **[2]**

(b) The graph shows how the groundspeed of another aircraft varies as it flies from Manchester to Cambridge.



(i) Which part of the graph shows the largest magnitude of acceleration?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

[1]

(ii) Calculate the distance travelled while the aircraft's groundspeed is 70 ms^{-1}.

distance travelled = ... m **[3]**

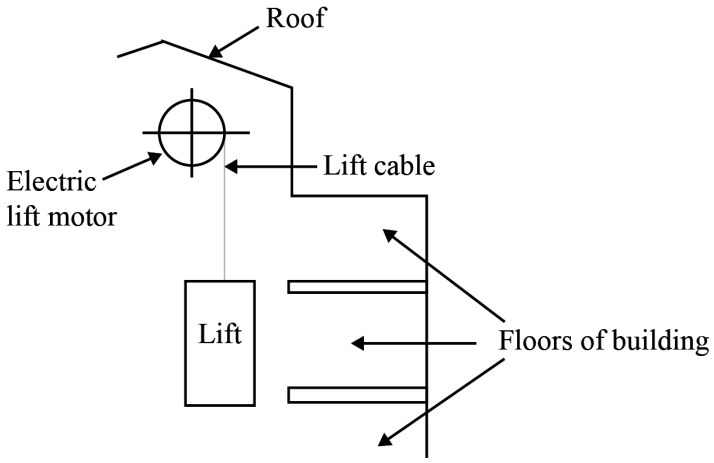
(c) The aircraft's engine develops the most power during take-off.

Define the term 'power'.

.....

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

3 A schematic diagram of the lift mechanism in a tall building is shown below.



(a) State **two** properties of materials that are important for the lift cable.

1 .....

2 .....

[2]

(b) The top floor is 30 m above the ground floor.

Calculate the energy required to lift a 75 kg person from the ground to the top floor.

energy = ... J **[2]**

(c) The electric lift motor is supplied from the 230 V mains supply.

(i) Define a volt.

.....

.....

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

(ii) The lift motor supplies 146 kJ carrying passengers for 42 s.

Calculate the average current input to the motor during this time.

current input = ... A **[3]**

(d) The electric lift motor is a large contribution to the building's electricity bill.

The bill is calculated from the number of kWh used.

What quantity can be measured in kWh?

Tick (✓) **one** box.

Charge	☐
Energy	☐
Potential	☐
Power	☐

[1]

(e) The electric lift motor has an efficiency of 40%.

(i) Define the term 'efficiency'.

.....

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

(ii) Calculate the required energy input to the motor to provide 32 kJ of output.

energy input = ... **kJ [2]**

(f) An energy company proposes the lift could be partly powered from a supercapacitor, charged from solar cells during the day.

The supercapacitor has capacitance 45 F.

Calculate the voltage across the capacitor when it stores 32 kJ of energy.

voltage = ... V **[3]**

4 Pylons are used to carry electricity distribution cables high above the ground.

The cables are made from aluminium. Aluminium is a ductile metal with a relatively high electrical conductivity.

(a) Explain what 'ductile' means.

.....

.....

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

(b) One such cable has cross-sectional area $1.3 \times 10^{-3}\,m^2$ and carries a current of 700 A.

Calculate the drift velocity of electrons in the cable.

The number of conduction electrons per unit volume in aluminium is $6.0 \times 10^{28}\,m^{-3}$.

drift velocity = ... ms^{-1} **[2]**

(c) This cable crosses a river supported on pylons.

The length of cable between the pylons is 1200 m.

The cable has a mass per unit length of $4.5\,\text{kg}\,\text{m}^{-1}$.

(i) Calculate the stress in the cable.

Assume the tension in the cable is due only to the weight.

stress = ... Pa **[3]**

(ii) Explain why it is important that the ultimate tensile stress of aluminium is greater than your answer to part **(c)(i)**.

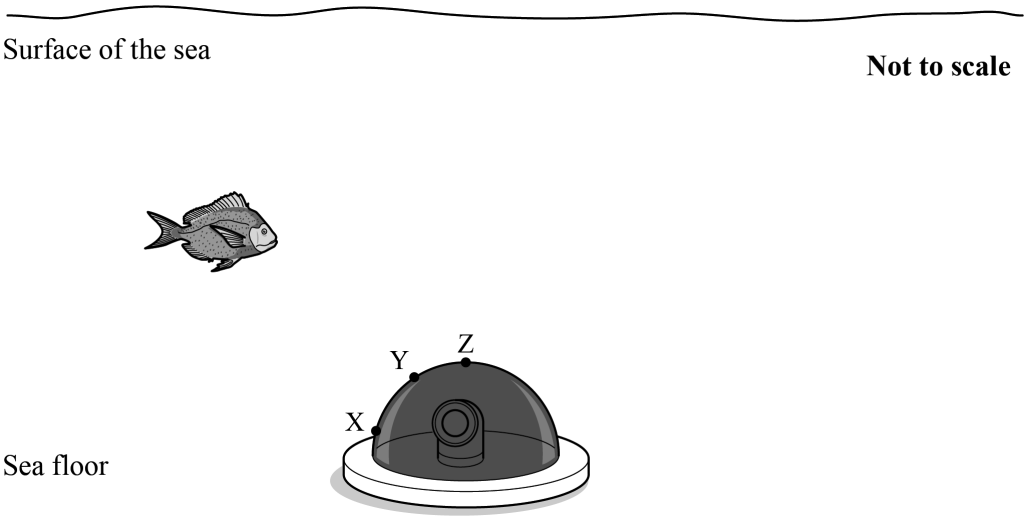
.....

.....

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

5 **Fig. 2** shows a camera placed on the sea floor to take photographs of marine animals.

Fig. 2



The camera is enclosed in a waterproof dome of plastic material.

(a) **(i)** Draw arrows on **Fig. 2** to show the direction of the pressure on the dome at the points X, Y and Z.

[2]

(ii) Calculate the pressure at Z due to the column of water above the dome.

Point Z is 64 m below the surface of the sea.

Density of sea water = 1200 kg m^{-3}.

Use an appropriate number of significant figures and give the correct unit.

pressure = ... unit ..... **[4]**

(iii) Explain why your answer to **(a)(ii)** is a **gauge pressure**.

.....

.....

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

(b) The dome is made of a material that retains its shape when submerged so that the camera images are not distorted.

State the name of this property of materials.

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

Turn over for the next question

6 A gas is stored in an expansion tank at constant pressure.

Gases are fluids.

(a) Name another kind of fluid.

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

(b) The volume of gas in the tank is $0.020\,m^3$ at $27\,°C$.

(i) Convert $27\,°C$ to Kelvin.

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

(ii) Calculate the volume of gas if the temperature falls to $-3\,°C$.

volume = ... m^3 **[2]**

(c) The gas cools further.

Energy is released as the gas condenses at its boiling point.

State in full the name given to the amount of energy released when 1 kg of the gas condenses at its boiling point.

.....

..... **[3]**

(d) What name is given to the temperature at which substances have minimum internal energy?

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

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(b)(ii) or 2(c).

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