OCR
Oxford Cambridge and RSA

Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 2: Science for engineering

Friday 12 January 2018 – Morning
Time allowed: 1 hour 30 minutes

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a protractor
- a scientific calculator

First Name						Last Name			
Centre Number						Candidate Number			
Date of Birth	D	D	M	M	Y	Y	Y	Y	

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **16** pages.

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

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Question 1 begins on page 3

Answer **all** the questions.

1 **(a)** Complete the table with the missing SI base units and physical quantities.

SI base unit	Physical quantity
metre	length
kilogram	
	time
ampere	
	temperature

[4]

(b) The mass of a container is measured five times.

The set of measurements taken are: 4.00 kg; 4.03 kg; 3.99 kg; 4.02 kg; 4.00 kg.

The known true mass of the container is 4.60 kg.

(i) Put a tick against the statement that describes the set of measurements in respect to its accuracy and precision.

Statement	tick
Precise and Accurate	
Imprecise and Inaccurate	
Precise and Inaccurate	
Imprecise and Accurate	

[1]

(ii) Explain your answer given in **(i)**.

.....

.....

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

(iii) Calculate the relative error for the first measurement of the series (4.00 kg).

Relative error = ... **[2]**

2 **(a)** A golf ball shown in Fig. 1 is hit from ground level with an initial velocity $u = 30\,\text{m s}^{-1}$ at an angle 60° to the horizontal.

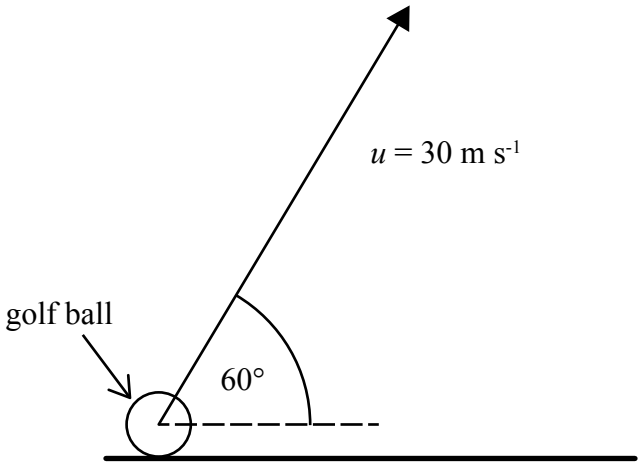

Fig. 1

Calculate

(i) the vertical component of the initial velocity u,

Vertical component of the initial velocity = ... m s^{-1} **[1]**

(ii) the time it will take the golf ball to reach maximum height,

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

(iii) the maximum height reached by the golf ball.

Maximum height = ... m **[2]**

(b) A wheel bolt needs to be tightened to a torque of 90 N m.

Calculate the values of forces F_1 and F_2 required to tighten the bolt using two different tools shown in Fig. 2.1 and Fig 2.2.

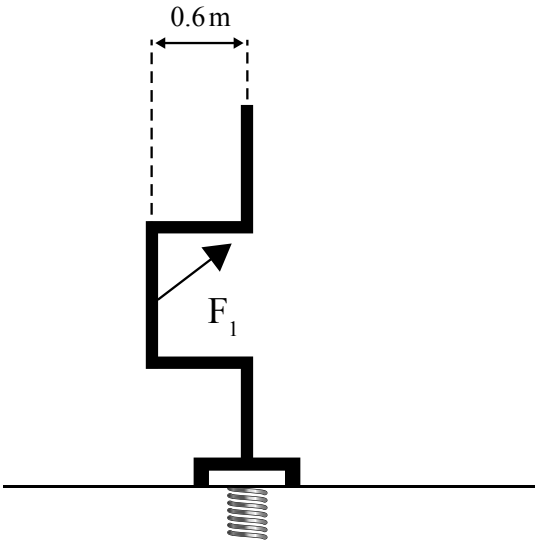

Fig. 2.1

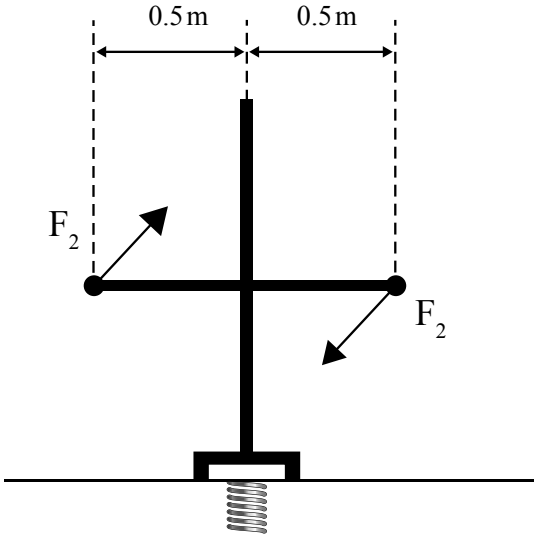

Fig. 2.2

Force F_1 = ... N

Force F_2 = ... N

[4]

3 **(a)** State Ohm's Law.

.....

.....

.....

.....

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

(b) Fig. 3 shows the variation of the resistance of a wire with temperature.

Draw a second line on Fig. 3 to show the variation of the resistance of a thermistor with temperature.

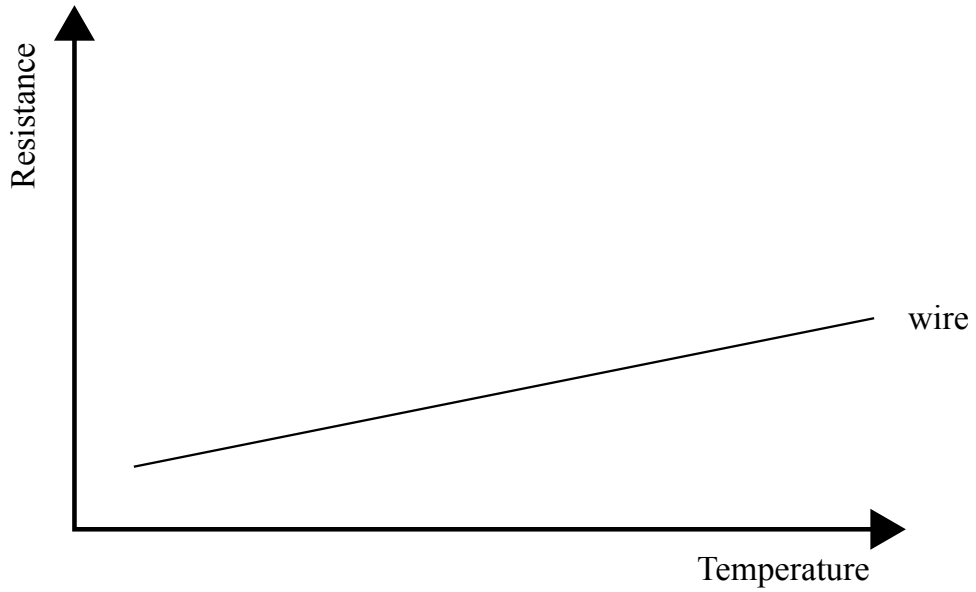

Fig. 3

[2]

(c) Fig. 4 shows two samples of material with identical dimensions.

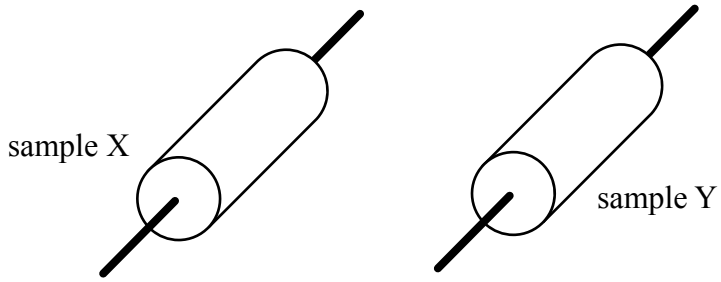

Fig. 4

They are connected in turn to a 1 V battery.

The current flowing through sample X is measured as 1 A, and the current through sample Y is 1 μA.

The two materials are known to be iron and silicon.

State and explain which material is iron.

Iron is sample: .....

Explanation .....

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

(d) A capacitor is charged from a 10 V power supply.

When fully charged, the total charge = 0.1 mC.

Calculate

(i) the capacitance of the capacitor,

Capacitance = ... **[2]**

(ii) the energy stored in the capacitor.

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

4 (a) Fig. 5 shows three force-extension curves for three different materials: **copper**, **cast iron** and **rubber**.

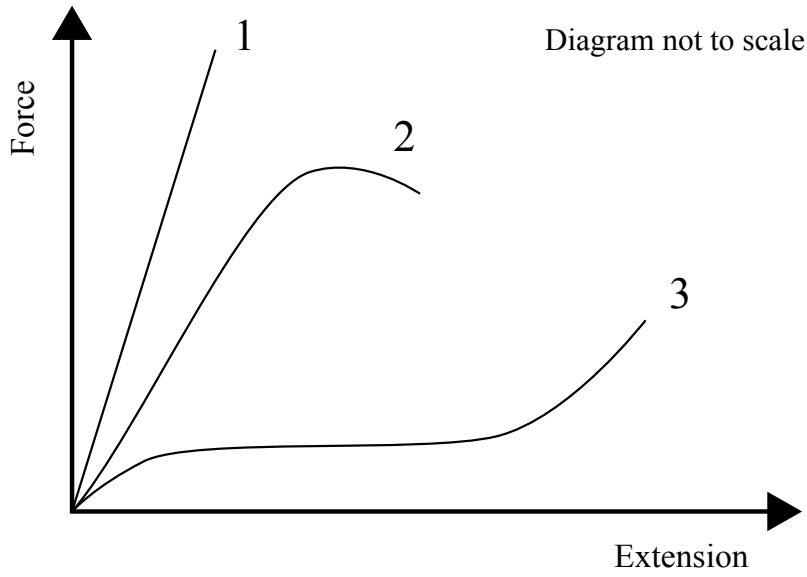

Fig. 5

Complete the table to match the material type to the corresponding force-extension curve shown in Fig. 5 and state which material (copper, cast iron or rubber) is which.

Curve number	Type of material	Material
	Brittle	
	Ductile	
	Polymeric	

[4]

(b) The strain energy U stored within a material undergoing elastic deformation is equal to the area under a force-extension curve as shown in Fig. 6.

Show that $U = \frac{1}{2} VE\varepsilon^2$

where $V =$ volume,

E = Young's modulus of the material,

ε = strain.

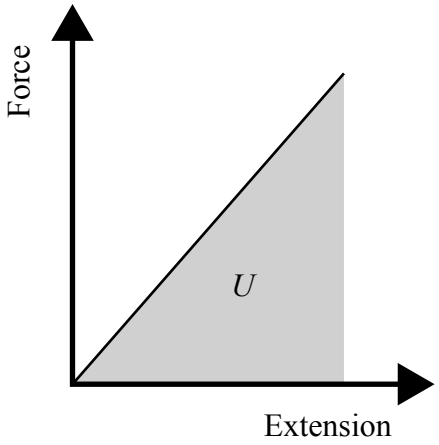

Fig. 6

[4]

(c) Engineering materials can be tested using either destructive testing (DT) or non-destructive testing (NDT).

(i) Explain why materials need to be tested.

.....

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

(ii) Describe the difference between destructive and non-destructive testing.

.....

.....

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

5 **(a)** Three spheres A, B and C, of different materials, are dropped into a container full of water and observed.

Sphere A floats on the surface.

Sphere B sinks to the bottom.

Sphere C becomes submerged and remains at a constant depth.

Complete the following relationships by placing a $\leq$, $=$ or $\geq$ symbol in the spaces provided.

- material density of sphere A …… density of water
- material density of sphere B …… density of water
- material density of sphere C …… density of water

[2]

(b) A diver finds a metal container at the bottom of a lake as shown in Fig. 7.

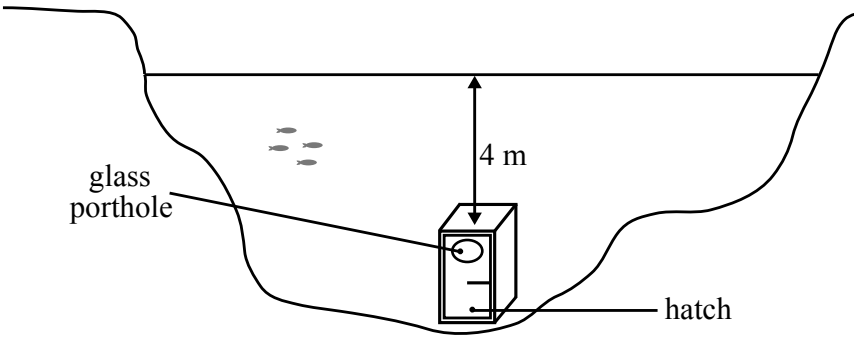

Fig. 7

(i) Calculate the resultant force acting on the hatch of the container if the depth of water above the container is 4 m.

Density of water = 1000 kg m^{-3}

The hatch is a rectangle with height 1.4 m and width 1.2 m.

Resultant Force = ... **[5]**

(ii) Suggest a method for decreasing the force required to open the hatch.

Explain your answer.

.....

.....

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

6 (a) A car tyre has been inflated to a pressure of 2.3 bar in a garage where the ambient temperature is 20 °C.

The volume of the air in the tyre is 0.055 m^3.

Specific gas constant for air R_{air} = 287 $J\,kg^{-1}\,K^{-1}$.

Specific heat capacity of air c_{air} = 718 $J\,kg\,K^{-1}$.

1 bar = 100 kPa

(i) Calculate the mass of air that was pumped into the tyre.

Mass of air = ... **[3]**

(ii) The car is then left on a driveway where the ambient temperature is 35 °C.

Calculate the new tyre pressure. Assume that the volume of the air in the tyre remains constant.

Pressure = ... Pa **[2]**

(iii) Calculate the amount of energy absorbed by air in the tyre to raise its temperature to 35 °C.

Energy absorbed = ... **[2]**

(b) During a meeting, 10 people are seated in a room.

Each person radiates thermal heat at a rate of 30 W.

Ten 120 W bulbs are switched on.

The heat loss through the walls and windows of the room is 2500 W.

An air conditioning unit is used to maintain the room at a constant temperature.

Calculate the rate at which the air conditioning unit is supplying or extracting heat.

State in your answer if the rate of heating is supplied or extracted.

Rate of heating = ... W ..... **[4]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown – for example 1(b) or 6(a).