

Cambridge **TECHNICALS LEVEL 3**

# ***ENGINEERING***

Cambridge  
**TECHNICALS**  
**2016**

Feedback on the January 2018 exam paper  
(including selected exemplar candidate answers  
and commentary)

Unit 2 – Science for engineering

Version 1

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## GENERAL EXAMINER COMMENTS ON THE PAPER

In general candidates seemed to make good use of the answer space available for calculation questions and it was easier to follow the working. There were several candidates who had power of ten errors or omitted units to numerical answers.

### Resources which might help address the examiner comments:

From the link below, you'll find 'The OCR guide to examinations' (along with many other skills guides)

<http://www.ocr.org.uk/i-want-to/skills-guides/>

Command verbs definitions

<http://www.ocr.org.uk/Images/273311-command-verbs-definitions.pdf>

## Question 1

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	mass
second	time
ampere	(electrical) current
Kelvin	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).

Precise because the values are all close to one another/repeatable/within small range/wtte.

Inaccurate because the values are not close to the true value.

[2]

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

Relative error = (Absolute error/true value)  
 = (measured value – true value)/true value  
 = (4.00 – 4.60)/4.60 = 0.13 or 13 %

[2]

**Mark scheme guidance****Question 1(a):**

Bold words represent what should be written in the table.

ACCEPT s (lower case) for second.

ACCEPT K (upper case) for Kelvin.

**Question 1(b)(i):**

Third box down ticked.

**Question 1(b)(ii):**

NOT they are not accurate to the true value.

If precision and inaccuracy are not mentioned in response, max 1 mark.

**Question 1(b)(iii):**

Evidence that this combination of equations has been used for first mark.

ACCEPT answer given as fraction (e.g. 3/23).

Ignore sign of final value.

**Examiner comments**

Question 1(a) – Common errors were to put weight for mass and Celcius or degrees for temperature. A few candidates put minutes for time.

Question 1(b) – Some candidates understood the difference between precision and accuracy but a few did not write their explanation particularly clearly. A few candidates got the two the wrong way round. Many candidates were able to calculate the relative error. Common mistakes were to divide by 4.00 instead of 4.60, or to find the ratio 4.00/4.60.

## Question 2(a)

- 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  $60^\circ$  to the horizontal.

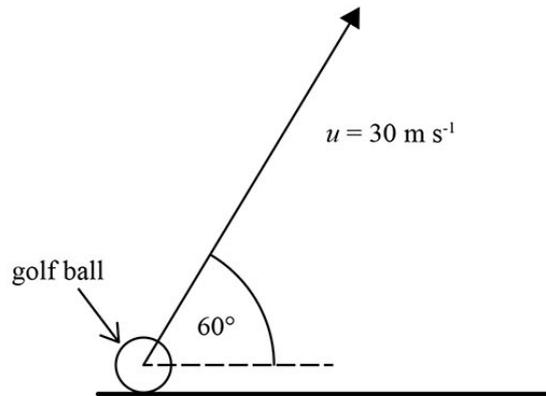


Fig. 1

Calculate

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

$$\text{Vertical component} = 30 \sin 60 = 26 \text{ m s}^{-1}$$

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

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

$$\begin{aligned} \text{Use of } v &= u + at \\ a &= - \text{acceleration of gravity} = -9.8 \text{ m s}^{-2} \\ t &= (0-26)/-9.8 = 2.65 \text{ s or } 2.7 \text{ s} \end{aligned}$$

Time = ..... s [3]

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

$$\begin{aligned} \text{Use of } s &= ut + \frac{1}{2}at^2 & \text{OR} \\ s &= (26)(2.65) + \frac{1}{2}(-9.8)(2.65)^2 = 34 \text{ m} & \text{Use of } s = \frac{1}{2}(u + v)t \\ \text{OR} & & s = \frac{1}{2}(26) 2.65 = 34 \text{ m} \\ \text{Use of } s &= vt - \frac{1}{2}at^2 & \text{OR} \\ s &= 0 - \frac{1}{2}(-9.8)(2.65)^2 = 34 \text{ m} & \text{Use of } v^2 = u^2 + 2as \text{ to give } s = \frac{(v^2 - u^2)}{2a} \\ & & s = -26^2 / (2 \times -9.8) = 34 \text{ m} \end{aligned}$$

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

**Mark scheme guidance****Question 2(a)(i):**

Actual value = 25.98

**Question 2(a)(ii):**

Allow ecf of velocity from part (i).

If  $u = 30\text{ms}^{-1}$ ;  $t = 3.1\text{s}$  for max 2 marks.

If  $a = -10\text{ms}^{-2}$ ;  $t = 2.6\text{s}$  for max 2 marks.

Bald answer of 3s for 1 mark.

**Question 2(a)(iii):**

ACCEPT  $s = 35\text{ m}$  (from early rounding).

Allow ecf for  $u$  and  $t$  used earlier.

[e.g. for  $u = 30\text{ ms}^{-1}$  and  $t = 3.1\text{ s}$ ; answer will be 47 or 46 m].

**Examiner comments**

Many candidates were able to calculate the vertical component of velocity correctly, but then did not use that value calculated in part (i) in the subsequent calculations. Although many candidates chose a suitable SUVAT equation from the formula booklet, some did not use the acceleration of gravity =  $9.8\text{ ms}^{-2}$ , which is given on the front page of the question paper.

## Question 2(b)

(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.

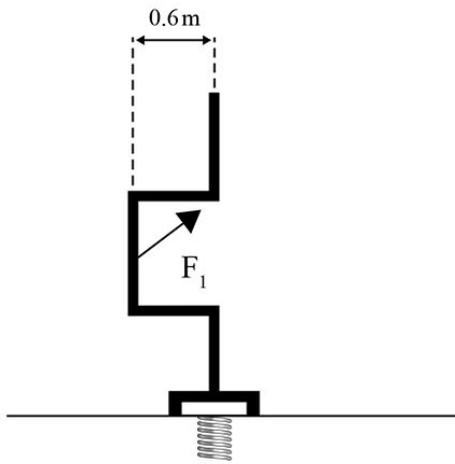


Fig. 2.1

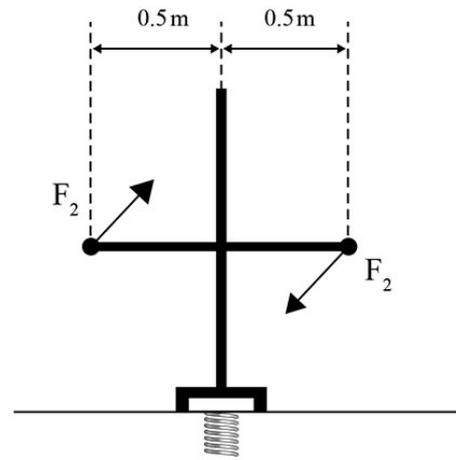


Fig. 2.2

Torque  $\tau = F r$  to give  $F = \tau/r$

$$F_1 = 90/0.6 = 150 \text{ N}$$

$$F_2 = F/2r = 90/(2)(0.5)$$

$$F_2 = 90 \text{ N}$$

Force  $F_1 = \dots\dots\dots$  N

Force  $F_2 = \dots\dots\dots$  N

[4]

**Mark scheme guidance**

Substitution of correct values into equation.

Use of  $2r$  in the equation for  $F_2$  as there are 2 forces applied.

A bald answer of  $F_2 = 90\text{N}$  will only gain this mark but not the previous calculation mark. Wrong method will not score either mark.

**Examiner comments**

The concept of torque was not well understood, and many calculations were not clearly laid out in this section. Despite that, some candidates were able to gain credit for the correct numerical answers.

Questions 3(a) and (b)

3 (a) State Ohm's Law.

Current through a conductor is proportional to the potential difference/voltage across it; (when) temperature remains constant.

.....  
 .....  
 ..... [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.

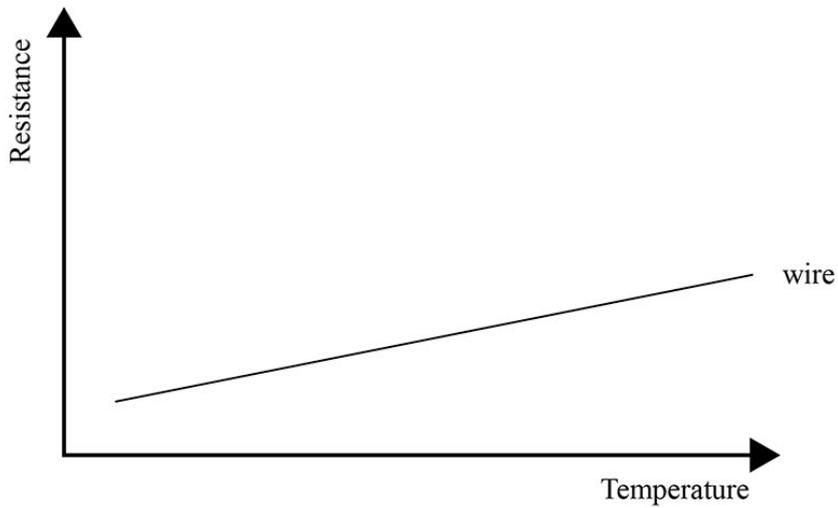
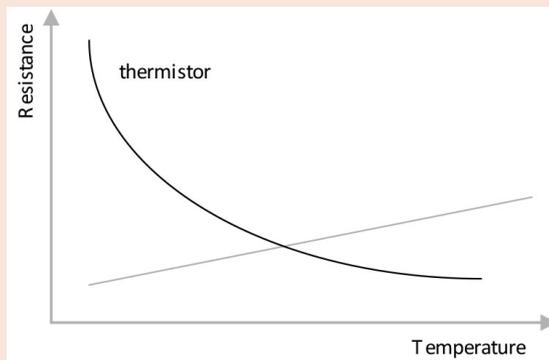


Fig. 3

[2]

Line drawn on axes.  
 Decreasing resistance with increase in temperature;  
 With a decreasing (negative) gradient as temp increases.



**Mark scheme guidance****Question 3(a):**

ACCEPT Voltage = current  $\times$  resistance (any subject). If symbols are used they must be defined.

**Question 3(b):**

A straight line with negative gradient would score 1 mark.

A line with increasing negative gradient would score 1 mark.

**Examiner comments**

Question 3(a) – Most candidates knew the relationship between voltage, current and resistance as Ohm's Law, but very few gained the second mark for including reference to a constant temperature.

Question 3(b) – There were a variety of different responses to this question. Some candidates did show that resistance of a thermistor decreased with temperature, but usually they drew a straight line instead of one with decreasing negative gradient.

Questions 3(c) and (d)

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

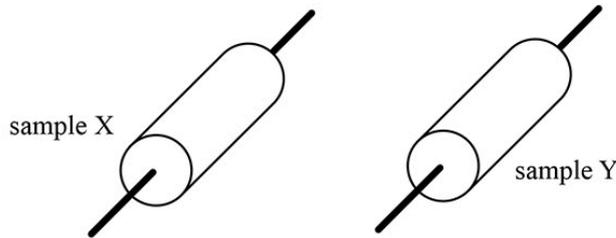


Fig. 4

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: . Sample X is Iron  
 Explanation ..... Iron is a conductor/metal so allows large(r) current/charge to flow .  
 ..... [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,

$$C = Q/V = 0.1/10$$

$$C = 0.01 \text{ mF or } 0.01 \times 10^{-3} \text{ F or } 1 \times 10^{-5} \text{ F}$$

Capacitance = ..... [2]

(ii) the energy stored in the capacitor.

$$E = \frac{1}{2}QV = \frac{1}{2}(0.1)(10)$$

$$E = 0.5 \text{ mJ} = 0.5 \times 10^{-3} \text{ J (or } 5 \times 10^{-4} \text{ J)}$$

OR

$$E = \frac{1}{2}CV^2 = \frac{1}{2}(0.01)(10)^2$$

$$E = 0.5 \text{ mJ} = 0.5 \times 10^{-3} \text{ J (or } 5 \times 10^{-4} \text{ J)}$$

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

## Mark scheme guidance

### Question 3(c):

NOT just iron is a (good) conductor; there must be some reference to increased current or charge flow.

e.g. 'conducts current better' is good enough for the mark. [Not conducts better].

### Question 3(d)(i):

Use of correct equation

Final answer with correct POT **and consistent unit**.

### Question 3(d)(ii):

Use of correct equation

Final answer to correct POT consistent with unit.

Allow ecf of incorrect C from part (i).

Omission of  $\times 10^{-3}$  for milli is only penalised once in part (d).

## Examiner comments

Question 3(c) – Most candidates correctly identified the sample of iron, but the explanations were not detailed enough. In order to gain the mark they needed to link the data given in the question about the relative currents flowing in the two materials to the fact that iron is a better conductor than silicon.

Question 3(d) – Most candidates were able to use the correct equations, but many omitted the unit, or failed to realise that the charge was given in milli-Coulomb. A few used an incorrect factor to convert milli-Coulomb to Coulomb. Some candidates used an incorrect equation ( $V = W/Q$ ) in part (ii).

## Exemplar Candidate Work

## Question 3(c) – High level answers

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

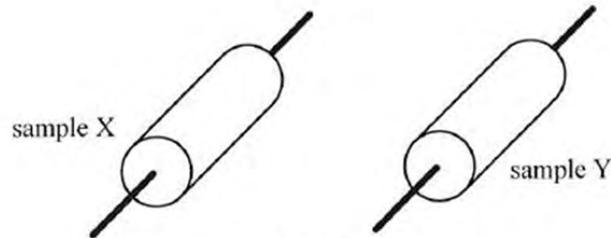


Fig. 4

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  $\mu$ A.

The two materials are known to be iron and silicon.

State and explain which material is iron.

Iron is sample: ..... ~~X~~ .....

Explanation .....

*Iron conducts electricity*

[2]

### Commentary

This candidate has correctly identified iron as sample X. However, the explanation should connect the observations recorded to the identification of the sample. In this case the property of iron needs to be related to the values of current given in the stem of the question. For example, a suitable explanation would be that as iron is a good conductor, it will allow a higher current to pass through.

## Exemplar Candidate Work

## Question 3(d)(i) – High level answers

(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,

$$C = \frac{Q}{V} = \frac{0.1}{10} = 0.01$$

Capacitance = ..... 0.01 ..... [2]

## Commentary

This candidate has correctly used the equation to calculate capacitance. However, there is no unit given for the final value. As the calculation uses a charge given in mC and the voltage is in V, the unit should be stated as mF.

## Question 3(d)(ii) – High level answers

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

When fully charged, the total charge = 0.1 mC.

Calculate

(ii) the energy stored in the capacitor.

$$W = \frac{1}{2} QV$$

$$= 0.5 \times (1 \times 10^{-3}) \times 10$$

Energy stored = .....  $5 \times 10^{-3}$  W ..... J [2]

## Commentary

This candidate has calculated correctly the value of energy stored in the capacitor. The value for charge Q has been converted correctly from 0.1 mC to  $0.1 \times 10^{-3}$  C. However, the candidate has added an incorrect unit to an answer line, which already has the correct unit.

## Question 4(a)

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

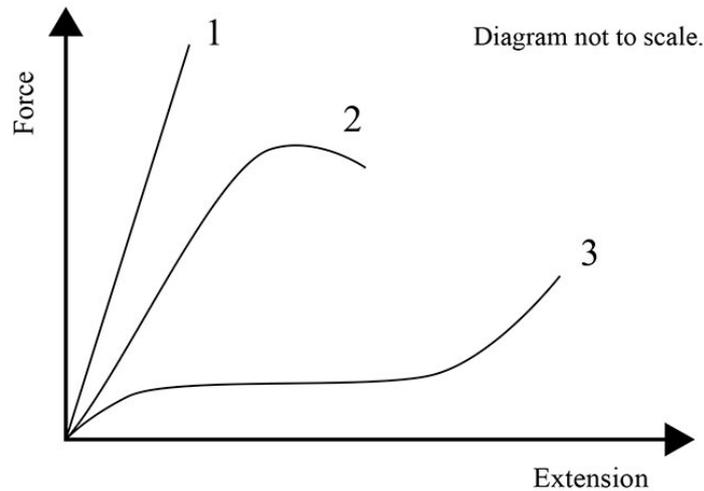


Fig. 5

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
1	Brittle	(Cast) Iron
2	Ductile	Copper
3	Polymeric	Rubber

[4]

**Mark scheme guidance**

**Curve number** – one correct number for 1 mark, all correct for 2 marks.

**Material** – one correct material for 1 mark, all correct for 2 marks. Only materials stated are correct – these are given in the question.

Answers to relate to middle column. No ecf from 1st to 3rd columns.

**Examiner comments**

Candidates were able to better identify the stated property with the materials rather than the shape of the force-extension curve.

Questions 4(b) and (c)

- (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  $U = \frac{1}{2} VE\epsilon^2$

where  $V =$  volume,

$E =$  Young's modulus of the material,

$\epsilon =$  strain.

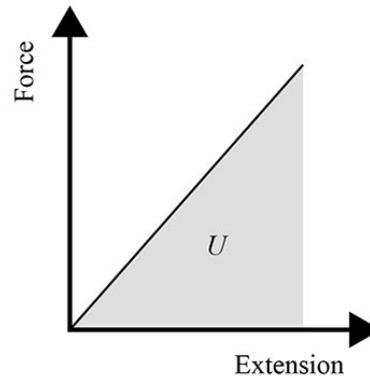


Fig. 6

This is a 'show that' question so the working must be shown.

( $U =$  area under graph  $\Rightarrow \frac{1}{2}Fx$ )

$F = \sigma A$  and  $x = L\epsilon$

Substitution:  $U = \frac{1}{2} (\sigma A)(L\epsilon) = \frac{1}{2} (AL) \sigma\epsilon (= \frac{1}{2} V \sigma\epsilon)$

Use of  $E = \sigma/\epsilon$  so substitute  $\sigma = E\epsilon$  to give  $U = \frac{1}{2}VE\epsilon^2$

OR reverse argument:

$\sigma = F/A$  and  $\epsilon = x/L$

$E = \sigma/\epsilon = (F/A)/(x/L) = FL/Ax$

Substitute into  $U = \frac{1}{2}VE\epsilon^2 = \frac{1}{2} (AL) (FL / Ax) (x^2/L^2)$

Simplify to  $U = \frac{1}{2} Fx^2$  which is area under graph.

[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.

To find characteristics/properties/behaviour of materials (or components).

[1]

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

Any 2 valid points e.g.:

- NDT does not result in failure of material or component/DT results in failure of material.
- DT used on samples of materials/NDT used on component in use.
- NDT can be used for continuous monitoring.
- DT is useful for determining physical properties such as UTS, ductility etc (any named physical property).
- NDT is used to find flaws/voids/discontinuities in components.
- NDT used for quality control in processing environment.

[2]

**Mark scheme guidance****Question 4(b):**

Any subject.

Using  $V = AL$

This mark can be awarded if  $E = \sigma/\epsilon$  and  $V=AL$  are substituted to give  $U = \frac{1}{2} (AL)(\sigma/\epsilon) \epsilon^2$

**Question 4(c)(i):**

Accept named (or described) property.

Ignore any reference to safety.

**Question 4(c)(ii):**

No credit for repeating question stem ie use of 'destroy'.

ACCEPT material/component can be used after NDT but not DT.

Credit other valid differences.

**Examiner comments**

Question 4(b) – Many candidates did not attempt this question, but some were able to gain credit for realising that the area under the graph =  $\frac{1}{2}$  Force  $\times$  extension, and for stating the equations used for finding stress and strain. Another mark was sometimes gained for substituting into the equation.

Question 4(c) – In general candidates found it difficult to explain why materials are tested, and most only gained one mark for describing one difference between non-destructive testing and destructive testing.

## Exemplar Candidate Work

## Question 4(b) – High level answers

- (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  $U = \frac{1}{2} VE\epsilon^2$

where  $V =$  volume,

$E =$  Young's modulus of the material,

$\epsilon =$  strain.

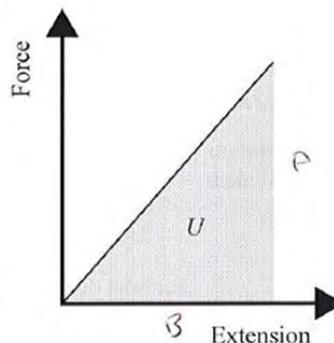


Fig. 6

$$\text{Stress} = \frac{\text{force}}{\text{area}}$$

$$\text{Strain} = \frac{\text{extension}}{\text{Original}}$$

$$\text{Young's} = \frac{\text{Stress}}{\text{Strain}} = \frac{\text{force} \times \text{extension}}{\text{area} \times \text{length}} \times \text{volume}$$

$$0.5 \times \frac{\text{Volume}}{\text{m}^3} \times \frac{\text{force}^{\text{N}} \times \text{extension}^{\text{m}}}{\text{volume}^{\text{m}^3}} \times \text{Strain}^2$$

$$= 0.5 \times \text{force} \times \text{extension} \times \text{strain}^2$$

area of right angle triangle =  $0.5 \times \text{Force} \times \text{extension}$

### Commentary

This candidate has made a start in the right direction, but the working is not well laid out.

On the right-hand side there is some working which states that the area under the line is equal to  $\frac{1}{2}$  force  $\times$  extension.

The candidate has correctly stated the equations for both stress and strain.

The candidate also correctly states that Young's modulus is equal to stress divided by strain, but there is an algebraic error in the substitution. This leads to an incorrect statement that  $\frac{1}{2}$  force  $\times$  extension  $\times$  strain<sup>2</sup> is equal to  $\frac{1}{2}$  force  $\times$  extension.

If the candidate had correctly substituted to give  $\text{Young's modulus} = \frac{\text{force} \times \text{length}}{\text{area} \times \text{extension}}$ ,

and then gone on to substitute this into the given expression  $U = \frac{1}{2} VE\epsilon^2$ , they could have gained more marks.

## Question 5(a)

- 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]

material density of sphere A  $\leq$  density of water  
material density of sphere B  $\geq$  density of water  
material density of sphere C  $=$  density of water

**Mark scheme guidance**

1 correct for 1 mark

All 3 correct for 2 marks.

Accept  $<$  instead of  $\leq$ , and  $>$  instead of  $\geq$ .

**Examiner comments**

This was generally well answered.

Question 5(b)

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

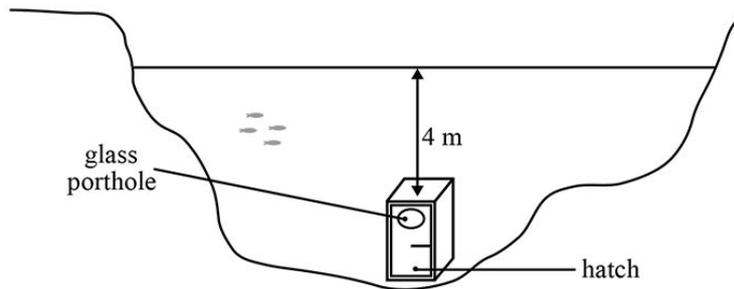


Fig. 7

(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 =  $1000 \text{ kg m}^{-3}$

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

Use of centre of the hatch to find  $h = 4 + 0.7 = 4.7 \text{ m}$

$P = \rho g h = (1000)(9.8)(4.7) = 4.61 \times 10^4 \text{ Pa}$

Hatch area calculation  $1.2 \times 1.4 = 1.68 \text{ m}^2$

Force =  $P \times A = 4.61 \times 10^4 \times 1.68 = 7.7 \times 10^4$   
(or  $4.6 \times 10^4 \times 1.7 = 7.8 \times 10^4$ )

N

Resultant Force = ..... [5]

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

Explain your answer.

Breaking the window/porthole. ....

Filling the safe with water reduces pressure difference between the inside and the outside (requiring less force to open the hatch). ....

.. [2]

**Mark scheme guidance****Question 5(b)(i):**

ACCEPT all values to 2sf.

Credit this mark if  $h = 4\text{m}$ ,  $P = 3.9 \times 10^4 \text{ Pa}$  and if  $h = 5.4 \text{ m}$ ,  $P = 5.3 \times 10^4 \text{ Pa}$ .

Allow ecf of incorrect pressure calculated

( $F = 6.6 \times 10^4$  or  $8.9 \times 10^4$  from examples above).

Correct unit, consistent with POT. (Independent mark).

**Question 5(b)(ii):**

ACCEPT:

Apply force on the hatch as far as possible from hinge (1); which gives a greater moment (1).

OR:

Decrease depth of safe (1); which reduces pressure on safe/hatch (1).

Do not accept changing dimensions of safe/window/hatch etc.

**Examiner comments**

Many candidates realised that they needed to find the pressure exerted by the water above the container, but most did not calculate the average depth of the container as 4.7m, but were able to gain the rest of the available marks. Some omitted the unit. Those who did not understand how to calculate the force were able to gain some of the marks for finding the area of the hatch and for putting the correct unit on the answer line. Some candidates did not gain any credit in part (ii) as their explanation required changing the dimensions of the container or the hatch, which is not an option in the scenario given in the question.

## Exemplar Candidate Work

## Question 5(b)(i) – High level answers

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

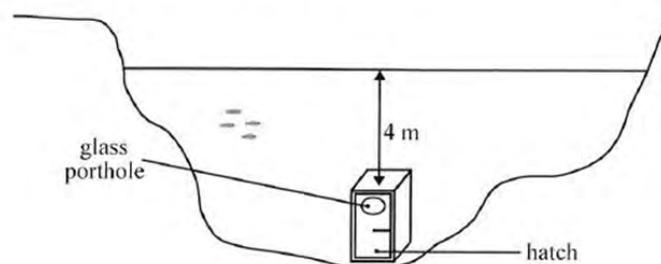


Fig. 7

- (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 =  $1000 \text{ kg m}^{-3}$

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

$$\begin{aligned}
 F &= \text{kg m s}^{-2} & G &= \text{m s}^{-2} & \text{kg m s}^{-2} &= \text{kg m}^{-3} \times \text{m} \times \text{m s}^{-2} \times \text{m}^2 \\
 \text{Density} &= \text{kg m}^{-3} \\
 \text{Area} &= \text{m}^2 & d &= \text{m} & F &= D \times d \times g \times A \\
 \text{kg m}^{-3} \times \text{m}^2 &= \text{kg m}^{-1} & 1000 \times 4 \times 9.8 \times (1.4 \times 1.2) &= 65856 \text{ N} \\
 \text{kg m}^{-1} \times \text{m s}^{-2} &= \text{kg s}^{-2} \\
 \text{kg s}^{-2} \times \text{m} &= \text{kg m s}^{-2}
 \end{aligned}$$

Resultant Force = 65856 N ..... [5]

### Commentary

This candidate has used an unusual method to work out how to calculate a force, using dimensional analysis. This is a useful technique if you don't know which equation to use in a calculation. The candidate has identified the base SI units for all the quantities given in the question on the top left and then worked out which quantities multiplied together will give an answer with the same base units as a force.

The symbols used are not the standard ones, but this candidate has correctly worked out that force = density × depth × acceleration of gravity × area.

A more conventional way to get to this equation is to combine the two equations: pressure due to a column of liquid = density × depth × acceleration of gravity and pressure = force ÷ area.

Having arrived at the correct equation to use, and in order to earn full marks, the candidate then needs to work out the average depth of the chest, not just the depth of water above the top of the chest. This means that the depth to use in the equation is 4.7 m, not 4.0 m.

This candidate has also correctly given the units which were omitted from the answer line.

## Exemplar Candidate Work

## Question 5(b)(ii) – High level answers

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

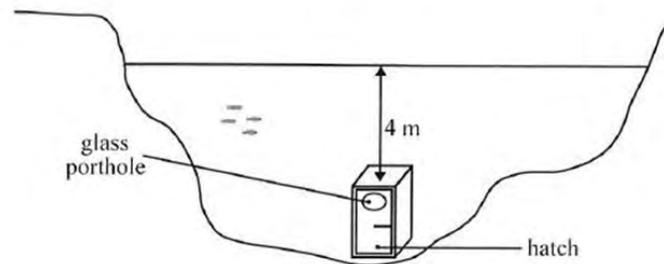


Fig. 7

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

Explain your answer.

You can use a long lever to open the hatch as it will ~~remove the~~ decrease the force necessary to open it. [2]

### Commentary

This is a valid method for reducing the force needed to open the hatch, however more detail is needed to explain why the force is reduced. Just repeating the question stem of 'decrease the force' is insufficient to gain the second mark.

In this case the explanation should have referred to the moment of a force, for example the moment of a force increases as distance between the force (or its point of application) and the pivot increases.

## Question 6(a)

- 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<sup>3</sup>.

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

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

1 bar = 100 kPa

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

Temperature: 20 °C = 293 K  
 Use of  $PV = mRT$  rearranged  $m = PV/RT$   
 $m = (2.3 \times 10^5)(0.055)/(287)(293) = 0.15 \text{ kg}$

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.

Use of  $P/T$  is constant or  $P_1/T_1 = P_2/T_2$   
 $P_2 = P_1 T_2 / T_1 = (2.3 \times 10^5)(308)/293 = 2.4 \times 10^5 \text{ Pa}$   
 OR:  
 Substituting into  $P = mRT/V = (0.15)(287)(308)/0.055$   
 $P = 2.4 \times 10^5 \text{ Pa}$

Pressure = ..... Pa [2]

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

Use of Energy  $Q = mc\Delta T = (0.15)(718)(35 - 20)$   
 $Q = 1.6 \times 10^3 \text{ J}$

Energy absorbed = ..... [2]

## Mark scheme guidance

### Question 6(a)(i):

If  $T = 20$  then  $m = 2.2$  kg for max 2 marks.

Final answer must **include a unit** consistent with POT.

### Question 6(a)(ii):

Temperature:  $35\text{ }^{\circ}\text{C} = 308\text{ K}$

If candidate has used temperature in Celcius in both parts (i) and (ii), only penalise in part (i). If not converted in part (ii) only, then max 1 mark here.

Allow ecf of incorrect POT pressure used in part (i).

Substitution consistent with part (i).

Allow ecf of incorrect mass calculated in part (i).

### Question 6(a)(iii):

Need to see a change in temperature.

Allow ecf of incorrect mass calculated in part (i).

Final answer must **include a unit**.

## Examiner comments

Some candidates did not convert the temperature into Kelvin and a few used an incorrect conversion. In part (i) there were several power of ten errors for the pressure with some candidates leaving the pressure in bar, some converting to kPa, and a few incorrectly used a pressure of 100kPa instead of 230 kPa. It was pleasing to see many candidates include the unit in this question. Many candidates used the ideal gas equation ( $PV = mRT$ ) again in part (ii), and some attempted to use the pressure law with mixed success. Many of these did not use the relationship correctly as they just calculated pressure/temperature or used volume as the constant. Part (iii) was well answered with most candidates using a temperature change in the equation correctly. A few used the temperature change of 288 instead of 15. Some candidates omitted a unit in their final answer. Some candidates incorrectly attempted to use the latent heat equation here instead of the specific heat capacity equation.

## Question 6(b)

(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.

Power supplied by people =  $10 \times 30 = 300\text{W}$  AND Power supplied by bulbs =  $10 \times 120 = 1200\text{W}$ .  
 Power leaving the system = Power entering the system ( $Q = W$  at constant temperature)  
 so  $2500 = (10)(30) + (10)(120) + X$   
 $X = 1000\text{ W}$   
 supplied

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

### Mark scheme guidance

Ignore sign of final answer.

Direction of heat flow.

### Examiner comments

This was generally well answered, with only a few candidates making mistakes.



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