

Cambridge **TECHNICALS LEVEL 3**

ENGINEERING

Cambridge
TECHNICALS
2016

Combined feedback on the June 2017 exam paper
(including selected exemplar candidate answers
and commentary)

Unit 2 – Science for engineering

Version 1

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INTRODUCTION

This resource brings together the questions from the June 2017 examined unit (Unit 2), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We have also included exemplar candidate answers with commentary for Questions 2b (i) (ii), 3a and 3b.

The marking guidance and the examiner's comments are taken from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from:

<https://interchange.ocr.org.uk/Modules/PastPapers/Pages/PastPapers.aspx?menuindex=97&menuid=250>

OCR
Oxford Cambridge and RSA

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

Unit 2: Science for engineering

Thursday 18 May 2017 – Afternoon
Time allowed: 1 hour 30 minutes

You must have

- The formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (centimetre)
- a protractor
- a scientific calculator

First Name: _____ Last Name: _____

Centre Number: _____ Candidate Number: _____

Date of Birth: _____

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 $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

FOR EXAMINER USE ONLY

Question No.	Mark
1	/10
2	/10
3	/10
4	/10
5	/10
6	/10
Total	60

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. Any blank pages are indicated.

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Unit 2: Science for engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for June 2017

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OCR Report to Centres June 2017

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GENERAL EXAMINER COMMENTS ON THE PAPER

In some of the calculation questions it can be difficult to follow the candidate's working which makes it more difficult to give credit where there is more than one mark available. It was good to see improvements from previous series in the use of units in numerical questions, but candidates still need to show more awareness with powers of ten. Both question 3 and 4 were well answered showing that many candidates had good understanding of both the electricity and material properties sections of the specification.

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>

Questions 1(a), (b) and (c)

Answer **all** the questions.**1 (a)** Convert the following units into their base SI units.**(i)** Pa (Pascal)kg m⁻¹ s⁻²

.....

..... [1]

(ii) W (Watt)kg m² s⁻³

.....

..... [1]

(b) Define the terms error and uncertainty in the context of measurement.**(i)** Error

Difference between the true value of a quantity and the value obtained by a measurement (wtte)

.....

..... [1]

(ii) Uncertainty

Range of values either side of a measurement in which the true value is expected to lie (wtte)

.....

..... [1]

(c) Name a property of fluids measured using a barometer.

..... Pressure

..... [1]

Question 1(d) and (e)

- (d) The current flowing through a circuit was measured a number of times. The results are given in the table below.

Current (A)	Frequency
10.0	1
10.2	2
10.4	4
10.6	3

- (i) Find the mean current.

$$\begin{aligned} \text{(Total current)} &= (10.0 + (10.2 \times 2) + (10.4 \times 4) + (10.6 \times 3)) = 103.8 \\ \text{Mean current} &= 103.8/10 = 10.38 \text{ (A)} \end{aligned}$$

..... [2]

- (ii) Find the standard deviation of these values.

$$\begin{aligned} \text{Sum of squares} &= 0.38^2 + 2(0.18^2) + 4(0.02^2) + 3(0.22^2) = 0.356 \\ \text{[Or: Sum of squares} &= \Sigma x^2 - n(\text{mean})^2 = ((10^2 + 2(10.2^2) + \\ &4(10.4^2) + 3(10.6^2)) - 10(10.38^2) = 1077.8 - 1077.444 = 0.356] \\ \text{Standard deviation} &= \sqrt{(0.356/n)} = \sqrt{(0.356/10)} = 0.189 \end{aligned}$$

..... [2]

- (e) A large component of steel bars is known to have a mean length of 425 mm with standard deviation 7.5 mm.

The length of the bars is tested by taking random samples of 10 bars.

What is the standard error of the mean?

$$\text{Standard error of the mean} = \text{standard deviation}/\sqrt{n} = 7.5/\sqrt{10} = 2.37$$

..... [1]

Mark scheme guidance

Question 1(a)(i):

Pressure = force/area; Pascal = $\text{kg m s}^{-2}/\text{m}^2$.

Question 1(a)(ii):

Power = energy/time = force \times distance/time

Watt = $\text{kg m s}^{-2} \text{ m/s}$

Question 1(b)(ii):

Allow range of values either side of a true value.

Question 1(d)(i):

First mark for totalling correctly.

3 sf minimum so accept 10.4. No ecf. $(10 + 10.2 + 10.4 + 10.6)/4$ is XP and scores zero.

Question 1(d)(ii):

Allow ecf from incorrect value of M in part (i).

Allow divide by 9 instead of 10. (SD = 0.199)

3sf minimum.

Question 1(e):

3sf minimum.

Examiners comments

Question 1(a) – Many candidates did not understand what was meant by conversion to base SI units. Some weaker candidates wrote down the property measured by each unit, and some did make an attempt to convert to equivalent units, but not necessarily the base SI units.

Question 1(b) – Candidates found it difficult to explain in words what is meant by error and uncertainty. More candidates were able to explain error.

Question 1(c) – Several candidates did not know that a barometer is used to measure pressure; a common incorrect answer was viscosity, and there were a number of responses which did not refer to a measured property such as 'water'.

Question 1(d) – Most candidates showed understanding of how to calculate the mean, but a common error was to ignore the frequency column in the table and just add the four values of current and then divide by 4. Finding the standard deviation seemed to be more difficult and some candidates who attempted the correct calculation, made arithmetic errors. Some candidates showed no working so may have used a scientific calculator to work out both mean and standard deviation.

Question 1(e) – This was difficult for most candidates, many of whom thought that this part carried on from part (d) and used the values calculated earlier in a calculation. Very few candidates answered this part correctly.

Question 2(a)

2 (a) A 1500kg car drives along a horizontal road at 72km h⁻¹.

(i) Calculate the kinetic energy of the car.

Convert 72 km/h to SI units
 $v = 72 \times 10^3 / 3600 = 20 \text{ m s}^{-1}$

Use of: $E_k = \frac{mv^2}{2}$

$$E_k = \frac{1500 \times 20^2}{2} = 3 \times 10^5 \text{ (J)}$$

[2]

(ii) If the resistive forces equate to a total of 500N calculate the power generated by the engine while the car is travelling at 72km h⁻¹.

$$P = Fv = 500 \times 20$$

$$P = 500 \times 20 = 1 \times 10^4 \text{ W} = 10 \text{ kW}$$

[2]

(iii) Once the brakes are applied and the power removed the car comes to a standstill within 30m. Calculate the braking force generated by the disc brakes. Consider the car as a point mass and assume that the resistive forces remain at 500N.

Either:
 Use of $W = Fs$ so $F = W/s$ and $W = 3 \times 10^5 \text{ J}$

$$F + 500 (= 3 \times 10^5 / 30 =) 1 \times 10^4, \text{ so } F = 9500 \text{ N}$$

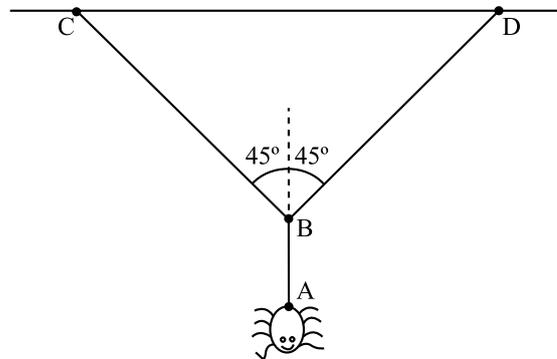
$$[\text{accept } F = 3 \times 10^5 / 30 = 1 \times 10^4 \text{ N} = 10 \text{ kN}]$$

[2]

Or: using suvat eqn $-a = u^2/2s$ to give $a = -6.7 \text{ ms}^{-2}$
 $F + 500 = ma$, so $F = (1500 \times 6.7) - 500 = 9500 \text{ N}$

Question 2(b)

- (b) A spider hangs on a strand of silk AB connected at 45° to strands CB and DB as shown in Fig. 1.



Not to scale

Fig. 1

- (i) The mass of the spider is 30 g. Calculate the weight of the spider.

$$W = mg = m \times 9.8$$

$$\text{Weight} = (30 \times 10^{-3}) (9.8) = 0.29 \text{ N}$$

[2]

- (ii) Calculate the tension in the strands CB and DB.

$$W = F_{CB} \cos 45^\circ + F_{DB} \cos 45^\circ$$

$$(F_{CB} = F_{DB} \text{ for symmetry})$$

$$W = 2 \times F_{CB} \cos 45^\circ$$

$$F_{CB} = F_{DB} = W / (2 \times \cos 45^\circ) = 0.29 / (2 \times 0.707)$$

$$F_{CB} = F_{DB} = 0.21 \text{ (N)}$$

[2]

Mark scheme guidance

Question 2(a)(i):

First mark for conversion.

Accept 1 sf here. Ignore unit.

If no conversion $E_k = 3.9 \times 10^6$ XP so no marks.

Question 2(a)(ii):

First mark for substituting into equation.

Allow ecf from part (i). If $v = 72$ used, $P = 3.6 \times 10^4$. Accept 1 sf here. **Unit required.**

Question 2(a)(iii):

First mark for choosing equation and realising that work done is equal to kinetic energy of the car – accept ecf from part (i).

Unit required.

Question 2(b)(i):

One mark for using the equation, ignoring POT of m.

Correct value to 2 sf with **unit** scores both marks.

Question 2(b)(ii):

Resolve forces vertically (Accept use of $\sin 45^\circ$).

Allow ecf of W from part i. Ignore unit.

If no division by 2 and $F = 0.42$ N award one mark only.

Examiners comments

Question 2(a)(i) – Whilst most candidates used the correct equation to calculate kinetic energy, many of them did not convert the speed in km h^{-1} to m s^{-1} , before carrying out the calculation. Another reasonably common error was to forget to square the speed.

Question 2(a)(ii) – It was good to see that most candidates attempted to use the correct equation to calculate power, and many of them included the units in the final answer.

Question 2(a)(iii) – This calculation proved difficult for many candidates. There was more than one way to work out this problem and there were a variety of attempts. This question in particular is one where candidates need to take care with their presentation, so that intermediate marking points can be gained.

Question 2(b)(i) – Most candidates realised how to calculate weight, but many did not include the unit or incurred a power of ten error.

Question 2(b)(ii) – Many candidates struggled with this calculation, and again if working was shown clearly candidates were able to gain credit for showing an intermediate step in their calculation.

Exemplar Candidate Work

Question 2(b) – low level answers

- (b) A spider hangs on a strand of silk AB connected at 45° to strands CB and DB as shown in Fig. 1.

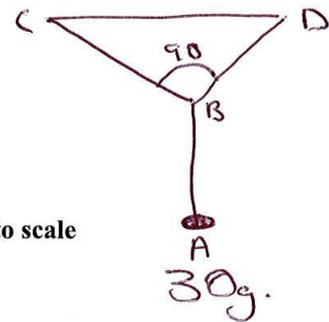
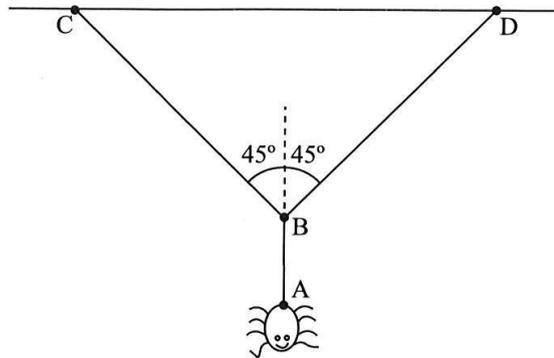


Fig. 1

- (i) The mass of the spider is 30 g. Calculate the weight of the spider.

$$\tan(45) \div 30 = 0.03$$

..... [2]

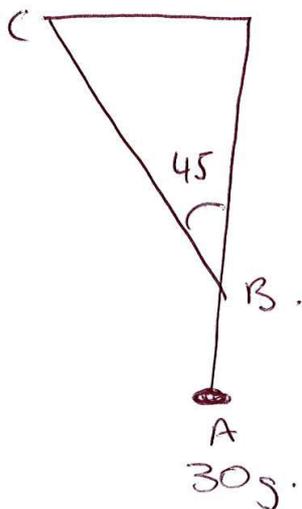
- (ii) Calculate the tension in the strands CB and DB.

~~$$\sin(45) \times 30 = 21.21 + 350 = A$$~~

$$\sin(45) \times 30 = 21.213$$

$$= 21.21$$

..... [2]



Commentary

Question 2(b)(i) – This candidate has attempted to use trigonometry in order to find the weight of the spider which is incorrect. The candidate should have multiplied the mass of the spider by the acceleration of gravity to calculate the weight of the spider.

Question 2(b)(ii) – This candidate has multiplied mass by $\sin 45^\circ$ without any explanation. If the candidate had multiplied the weight value calculated in the part (i) by $\sin 45^\circ$ a mark could have been awarded.

Exemplar Candidate Work

Question 2(b) – medium level answers

- (b) A spider hangs on a strand of silk AB connected at 45° to strands CB and DB as shown in Fig. 1.

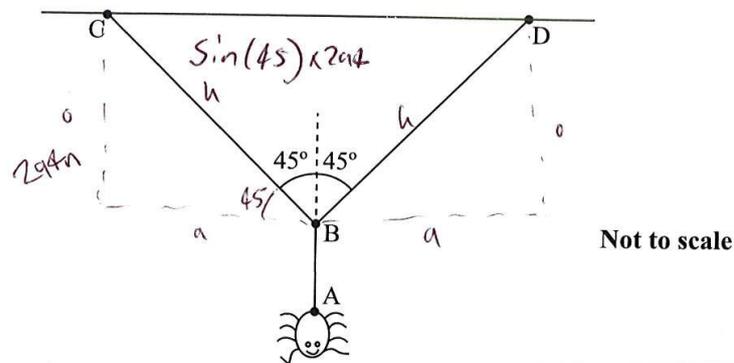


Fig. 1

- (i) The mass of the spider is 30 g. Calculate the weight of the spider.

$$\begin{aligned} \cancel{30} &= \cancel{9.8} = \cancel{3.06 \text{ kg}} \\ 30 \times 9.8 &= 294 \text{ N} \end{aligned}$$

[2]

- (ii) Calculate the tension in the strands CB and DB. $CB = DB$



$$\begin{aligned} (T) F &= 0.294 \text{ N} & CB &= 0.416 \text{ N} \\ \cos 45 &= \frac{0.294}{T} & DB &= 0.416 \text{ N} \\ T &= \frac{0.294}{\cos 45} \\ T &= 0.416 \text{ N} \end{aligned}$$

[2]

Commentary

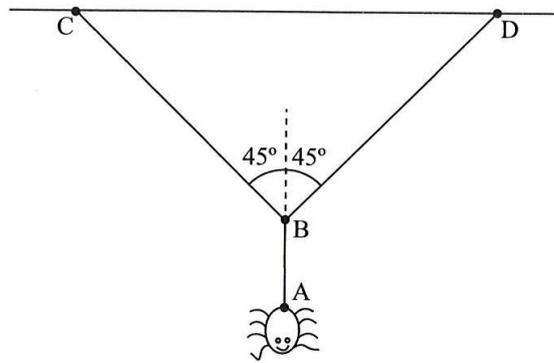
Question 2(b)(i) – This candidate has multiplied the mass of the spider by the acceleration of gravity which is the correct method to find the weight of the spider. However, the mass needs to be converted to kilogram to give an answer in Newton, which should have the unit capital **N**.

Question 2(b)(ii) – This candidate has sketched a triangle of forces showing correctly that the tension is the hypotenuse of the force triangle, but has not accounted for the fact that there are two strands so the force calculated (0.416 N) needs to be halved. The tension in each strand has equal magnitude.

Exemplar Candidate Work

Question 2(b) – high level answers

- (b) A spider hangs on a strand of silk AB connected at 45° to strands CB and DB as shown in Fig. 1.



Not to scale

Fig. 1

- (i) The mass of the spider is 30 g. Calculate the weight of the spider.

$$9.8 \times 0.03 = \underline{\underline{0.294 \text{ N}}}$$

[2]

- (ii) Calculate the tension in the strands CB and DB.

$$0.294 = 2(\cos 45^\circ)$$

$$\frac{0.294}{2(\cos 45^\circ)} = T = 0.207894$$

$$\text{BC + BD } T = \underline{\underline{0.208 \text{ N}}}$$

[2]

Commentary

Question 2(b)(i) – This answer is correct. Acceleration of gravity (9.8) is multiplied by mass in kilogram (0.03) to give the weight of 0.294 and the unit **N** is given.

Question 2(b)(ii) – This candidate has taken the two strands into consideration at the beginning of the calculation, and give the correct value for tension in each strand.

Question 3(a)

- 3 (a) Three resistors R_1 , R_2 and R_3 are connected to a 50V power supply as shown in Fig. 2.

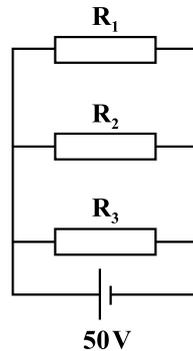


Fig. 2

You are given that $R_1 = 20\ \Omega$, $R_2 = 40\ \Omega$ and $R_3 = 50\ \Omega$.

Calculate

(i)
$$\frac{1}{R_0} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{20} + \frac{1}{40} + \frac{1}{50} \quad / \quad \frac{1}{R_0} = 0.095$$

$R_0 = 10.5\ (\Omega)$

[2]

- (ii) the total current flowing through the power supply,

$$I = V/R$$

$$I = 50 / 10.5$$

$$I = 4.8\ \text{A}$$

[2]

- (iii) the current flowing through R_2 ,

$$I = V/R$$

$$I_2 = 50 / 40$$

$$I_2 = 1.25\ \text{A}$$

[2]

- (iv) the power dissipated in R_2 .

$$P = I^2 R \text{ or } P = IV \text{ or } V^2/R$$

$$P = 1.25^2 \times 40 \text{ or } P = 1.25 \times 50 \text{ or } P = 50^2/40$$

$$P = 63\ \text{W}$$

[2]

Question 3(b)

- (b) Calculate the electric resistance of a 10 metre long copper wire with a cross section area of 3.15 mm^2 .

Resistivity of copper is $\rho = 1.68 \times 10^{-8} \Omega \text{ m}$.

$$\rho = RA/l \text{ rearranged to give } R = \rho l/A$$

$$= 1.68 \times 10^{-8} \times 10 / 3.15 \times 10^{-6}$$

$$R = 0.053 \Omega$$

.....

.....

..... [2]

Mark scheme guidance

Question 3(a)(i):

No mark for quoting equation.

First mark awarded for correct substitution into equation.

Second mark for final value – no ecf. Accept 2sf so 11Ω is okay.

If $R = 0.095$ this is XP so no marks awarded.

Question 3(a)(ii):

No mark for quoting equation.

First mark for substitution.

Second mark for correct value and unit. If correct unit in part (iii) ignore unit here.

Allow ecf from incorrect answer in part (i).

Question 3(a)(iii):

No mark for quoting equation.

First mark for substitution of 50 V and a value of resistance of an individual resistor.

Second mark for correct value and unit. If correct unit in part (ii) ignore unit here. Only penalise incorrect unit once in parts (ii) and (iii).

Question 3(a)(iv):

No mark for quoting equation.

First mark for substitution. Allow ecf of value for I or R used in part (iii).

Ignore unit.

Question 3(b):

First mark for substitution into equation (ignore incorrect POT).

Correct POT and consistent unit required for second mark.

Final value of $5.3 \times 10^{-8} \Omega$ or $5.3 \times 10^{-5} \Omega$ would score 1 mark for POT error.

Examiners comments

Question 3(a) – Many candidates showed some understanding of how to calculate total resistance for multiple resistors in parallel, but there were some mathematical errors. Nearly all the candidates were able to gain some marks for calculating current and power correctly in parts (ii) to (iv).

Question 3(b) – Many candidates were able to correctly use the equation, but there were some power of ten errors.

Exemplar Candidate Work

Question 3(a) – low level answer

- 3 (a) Three resistors R_1 , R_2 and R_3 are connected to a 50V power supply as shown in Fig. 2.

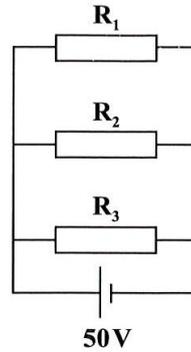


Fig. 2

You are given that $R_1 = 20 \Omega$, $R_2 = 40 \Omega$ and $R_3 = 50 \Omega$.

Calculate

- (i) the effective resistance in the circuit,

$$\begin{aligned} R_1 + R_2 + R_3 &= 110 \\ R &= \frac{R_1 R_2 R_3}{R_1 R_2 + R_2 R_3 + R_1 R_3} = 110 \end{aligned}$$

..... [2]

- (ii) the total current flowing through the power supply,

$$P = \frac{VI}{50} = \frac{50}{110} = 0.45$$

..... [2]

- (iii) the current flowing through R_2 ,

$$40$$

..... [2]

- (iv) the power dissipated in R_2 .

$$70$$

..... [2]

Commentary

In part (i) this candidate has added all the individual resistance together which would give the total resistance if the resistors were connected in series. These resistors are connected in parallel so this is the incorrect method.

In part (ii) the candidate has used the correct equation $I = V/R$ with the value of total resistance carried forward from part (i) which gets the first marking point. The value for current should include a unit so the answer is 0.45 A in this case.

In parts (iii) and (iv) no working is shown and the values written are incorrect so no marks can be awarded.

Exemplar Candidate Work

Question 3(a) – medium level answer

- 3 (a) Three resistors R_1 , R_2 and R_3 are connected to a 50V power supply as shown in Fig. 2.

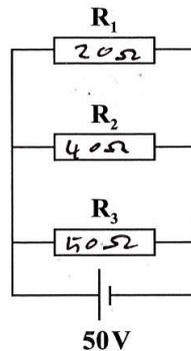


Fig. 2

You are given that $R_1 = 20\Omega$, $R_2 = 40\Omega$ and $R_3 = 50\Omega$.

Calculate

- (i) the effective resistance in the circuit,

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

$$\frac{1}{R_T} = \frac{1}{20} + \frac{1}{40} + \frac{1}{50} = 0.095$$

$$R_T = 10.526315789473684210$$

$$= 10.5 \text{ (3 s.f.)}$$

[2]

- (ii) the total current flowing through the power supply,

$$I = \frac{V}{R} \quad I = \frac{50}{10.5} \quad I = 4.76$$

[2]

- (iii) the current flowing through R_2 ,

$$2 : 4 : 5 = 11$$

$$\frac{4.76}{11} \times 2 = 0.86545$$

$$0.86545 \text{ A}$$

$$= 0.87 \text{ A (2dp)}$$

[2]

- (iv) the power dissipated in R_2 .

$$V = IR$$

$$V = 0.87 \times 20 \quad V = 17.316017$$

$$V = 17.32 \text{ (2dp)}$$

[2]

Commentary

This candidate has shown clear working in part (i) and has the correct answer with correct unit, so gains both marks.

In part (ii) the calculation of current is correct but there is a missing unit. The answer should be 4.76 A. However the candidate has included the correct unit in the answer to part (iii) so there is no penalty here.

In part (iii) the candidate has assumed (incorrectly) that the current through the power supply is split in proportion to the resistance in each branch of the circuit. This is not the case as current is inversely proportional to resistance ($I = V/R$). The easiest method to find the current in R_2 is to divide the potential difference (50 V) by the value of resistance (40Ω).

In part (iv) the candidate has used a correct method but is calculating the power dissipated in resistor R_1 for the current calculated in part (iii).

Exemplar Candidate Work

Question 3(a) – high level answer

- 3 (a) Three resistors R_1 , R_2 and R_3 are connected to a 50V power supply as shown in Fig. 2.

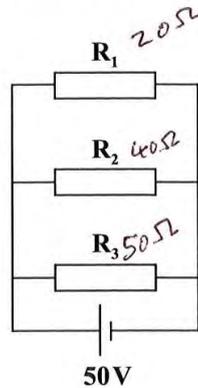


Fig. 2

You are given that $R_1 = 20\Omega$, $R_2 = 40\Omega$ and $R_3 = 50\Omega$.

Calculate

- (i) the effective resistance in the circuit,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \approx \frac{1}{20} + \frac{1}{40} + \frac{1}{50} \approx 0.095$$

$$R = 10.526 \Omega$$

- (ii) the total current flowing through the power supply,

$$I = \frac{V}{R} = \frac{50}{10.53} \approx 4.74 \text{ A}$$

- (iii) the current flowing through R_2 ,

$$I = \frac{50}{40} \approx 1.25 \text{ A}$$

- (iv) the power dissipated in R_2 .

$$P = VI \approx 50 \times 1.25 \approx 60.25 \text{ W}$$

Commentary

This candidate has shown the correct working and final value for the total resistance in the circuit in part (i). There has also been a correction to the rounding so the value is correct and this gains both marks.

However there is a rounding error in part (ii). The correct calculation has been carried out but the value should be 4.75 A so this loses one mark.

Parts (iii) and (iv) are correct and the final answers have the correct units and are rounded correctly.

Exemplar Candidate Work

Question 3(b) – low level answer

- (b) Calculate the electric resistance of a 10 metre long copper wire with a cross section area of 3.15 mm^2 .

Resistivity of copper is $\rho = 1.68 \times 10^{-8} \Omega \text{ m}$.

$$\rho = RA/l$$

$$\rho = \frac{1.68 \times 10^{-8} \times 3.15 \times 10^{-3}}{10} = 5.292 \times 10^{-12} \text{ } \rho \text{ } \Omega \text{ m}$$

[2]

$$\rho = 5.292 \Omega \text{ m}$$

Commentary

The equation written on the first line is correct, but this candidate has confused the terms resistance (R) and resistivity (ρ). The value for resistivity has been substituted into the equation where resistance should have been so this is incorrect. The candidate should have rearranged the equation to give resistance (R) as the subject of the equation. This would give $R = \rho l / A$.

Exemplar Candidate Work

Question 3(b) – medium level answer

- (b) Calculate the electric resistance of a 10 metre long copper wire with a cross section area of 3.15 mm^2 .

Resistivity of copper is $\rho = 1.68 \times 10^{-8} \Omega \text{ m}$.

$$1.68 \times 10^{-8} = \frac{R \times 10}{3.15 \text{ mm}^2 = 0.0315 \text{ m}^2}$$

$$1.68 \times 10^{-7} = R \times 0.0315 \text{ m}^2$$

$$1.68 \times 10^{-7} \div 0.0315 = \underline{5.33 \times 10^{-6}} \quad [2]$$

Commentary

This candidate has used the correct equation and substituted dimensionally correct values into the equation. However, there is an error in the conversion of mm^2 to m^2 . $3.15 \text{ mm}^2 = 3.15 \times 10^{-6} \text{ m}^2$. This means that the final value is out by a factor of $10^4 \Omega$, and there is no unit either.

Exemplar Candidate Work

Question 3(b) – high level answer

- (b) Calculate the electric resistance of a 10 metre long copper wire with a cross section area of 3.15 mm^2 .

Resistivity of copper is $\rho = 1.68 \times 10^{-8} \Omega \text{ m}$.

$$R = \frac{\rho l}{A} = \frac{1.68 \times 10^{-8} \times 10}{3.15 \times 10^{-6}} \quad 3.15 \text{ mm}^2 \Rightarrow 3.15 \times 10^{-6} \text{ m}^2$$

$$= 0.053$$

$$\approx 0.053 \text{ (Rsf)} \approx 0.053 \Omega \quad [2]$$

Commentary

This calculation is clearly laid out and the conversion of the area to m^2 is correct and the final value has the correct unit.

Question 4(a)

- 4 (a) Fig. 3 shows a beam subjected to a tensile load of 70kN.
The beam has a square cross section 10mm by 10mm and an initial length of 1m.

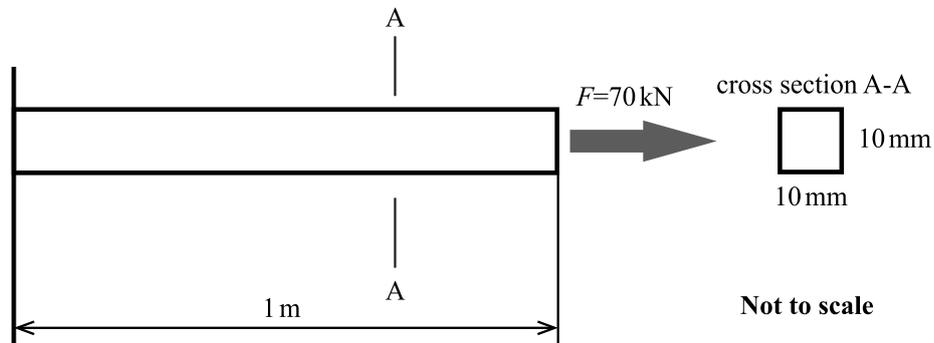


Fig. 3

The length of the beam increases by 100 μm due to loading.

Calculate

- (i) the strain on the beam,

$$\varepsilon = \frac{\Delta l}{l}$$

Extension = 100×10^{-6} (m)

$$100 \times 10^{-6} / 1 = 100 \times 10^{-6} = 1 \times 10^{-4}$$

[2]

- (ii) the stress across section A-A,

$$\sigma = F/A$$

Correct substitution of Force and area into equation, ignoring POT.

$$(A = (10 \times 10^{-3})^2 = 1 \times 10^{-4} \text{ m}^2)$$

$$70000 / (1 \times 10^{-4}) = 7 \times 10^8 \text{ Pa or Nm}^{-2} \text{ or (700 MPa or Nmm}^{-2})$$

[2]

- (iii) Young's modulus of the material of the beam.

$$E = \sigma/\varepsilon$$

$$E = 7 \times 10^8 / 100 \times 10^{-6}$$

$$E = 7 \times 10^{12} \text{ (Pa)}$$

[2]

Question 4(b)

(b) Fig. 4 shows the stress-strain curves for three different materials A, B and C.

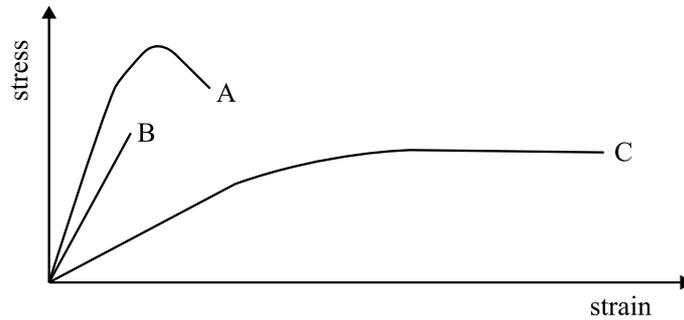


Fig. 4

(i) Which material has the highest ultimate tensile strength?

A [1]

(ii) Which material is the most brittle?

B [1]

(iii) Which material is the most ductile?

C [1]

(iv) Which material has the highest Young's Modulus?

A [1]

Mark scheme guidance

Question 4(a)(i):

No mark for quoting formula.

Award mark converting extension and original length to the same POT.

Award second mark for correct method for calculating strain.

One mark in total if incorrect POT error. Ignore any unit given.

Question 4(a)(ii):

No mark for quoting formula.

Correct POT and consistent unit required.

Question 4(a)(iii):

No mark for quoting formula.

Award mark for correct use of formula.

Allow ecf for incorrect values for stress and strain calculated in parts (i) and (ii). Ignore unit.

Examiners comments

Question 4(a) – Some candidates found it difficult to extract the correct data from the information given on the diagram. Also, many candidates did not ensure that all the length measurements were in consistent units before tackling the calculations in parts (i) and (ii). However, most were able to distinguish stress from strain and go on to calculate Young Modulus in part (iv).

Question 4(b) – This question was well answered on the whole.

Question 5(a)

- 5 (a) The three containers in Fig. 5 are filled with the same fluid to the same level.

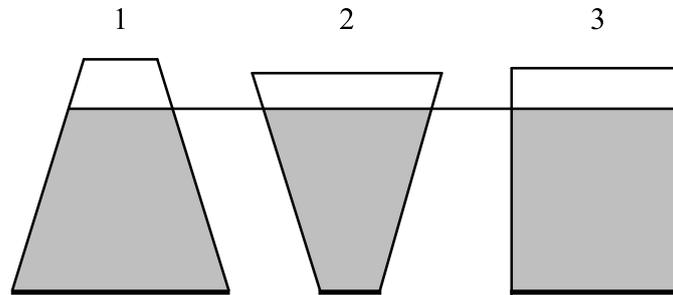


Fig. 5

Which of the following statements is true?

Put a tick (✓) in the box next to the correct statement.

Pressure at bottom of container 1 is the highest.

Pressure at bottom of container 2 is the highest.

Pressure at bottom of container 3 is the highest.

The pressure at the bottom of all three containers is identical.

[1]

- (b) Explain the terms 'gauge pressure' and 'absolute pressure'.

Gauge pressure is the pressure measured/seen on meter/gauge.

Absolute pressure is the sum of gauge and atmospheric pressure.

.....

 [2]

Question 5(c)

- (c) Fig. 6a shows a cube suspended from a spring force meter in air. The meter reading is 50 N.
 Fig. 6b shows the cube submerged in water. The meter now reads 20 N.
 Density of water = 1000 kg m⁻³

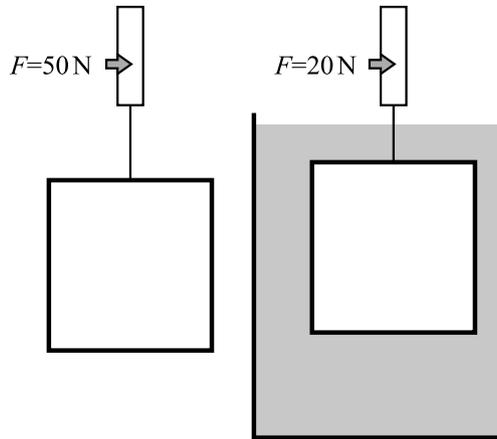


Fig. 6a

Fig. 6b

- (i) What is the upthrust force acting on the cube when it is submerged in water?

Upthrust force = 50 – 20 = 30 (N) [1]

- (ii) Calculate the volume of the cube.

Upthrust = volume of cube × g × density of water
 Volume = Upthrust / (ρ g)
 V = 30 / (1000 × 9.8)
 V = 0.0031 m³ (or 3100 cm³) [3]

- (iii) Calculate the density of the material of the cube.

Density of cube = mass/volume
 Mass of cube = weight / g = 50/9.8 = 5.1 kg
 Density = 5.1/0.0031 = 1700 kg m⁻³ [2]

- (iv) What is the direction of hydrostatic pressure in respect to the surface of the submerged cube?

Hydrostatic pressure acts towards the surface(s) of submerged body. [1]

Mark scheme guidance

Question 5(a):

Bottom box contains tick.

Question 5(b):

“Absolute pressure = gauge pressure + atmospheric pressure” in any form will score one mark max.

Question 5(c)(i):

Ignore unit.

Question 5(c)(ii):

Use of correct equation.

Correct substitution into equation.

Unit required

Question 5(c)(iii):

Mark for calculating mass of cube. If 30N or 20N used for weight this is XP and scores zero in this section.

Unit required. If 50 used as mass then award one mark here.

Question 5(c)(iv):

Can be shown on diagram.

Examiners comments

Question 5(a) – There were a variety of responses to this question.

Question 5(b) – Most candidates were able to gain one mark here for understanding the relationship between gauge pressure and absolute pressure, but few were able to explain what is meant by the term gauge pressure.

Question 5(c) – Many candidates showed good understanding in this question, and were able to correctly calculate both volume and density of the cube. There were some errors with powers of ten or omitted units. Some candidates used the incorrect value of force. Common incorrect answers were ‘downwards’ or ‘upwards’, showing that there may have been some confusion between upthrust and pressure.

Questions 6(a)

- 6 (a) (i) Explain the term 'latent heat' in context of thermodynamics.

Latent heat is energy released or absorbed by the substance at constant temperature resulting in a phase/state change.

[1]

- (ii) Fig. 7 shows a temperature/time graph for a material.
Which section of the graph (1, 2 or 3) represents latent heat absorption?

2

[1]

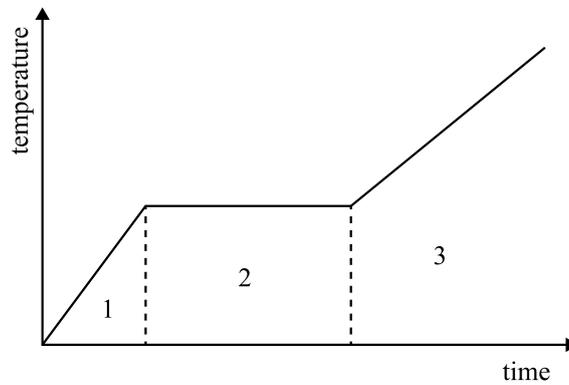


Fig. 7

Questions 6(b)

- (b) A 2kW heater is used to heat 10kg of air within a rigid box.

The efficiency of the heater is 85%.

The box loses heat energy to the surroundings at a constant rate of 600 J s^{-1} .

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

- (i) Calculate the amount of power supplied by the heater.

Power output = efficiency \times power input

Power output = 0.85×2000

Power output = 1700 (W)

[2]

- (ii) How much heat energy is required to heat up 10kg of air by 10°C ?

Heat required to increase the temperature by 10°C :

$Q_0 = m c \Delta T$

$Q_0 = 10 \times 718 \times 10$

$Q_0 = 71800 \text{ (J)}$

[2]

- (iii) Calculate the time taken to heat the air by 10°C .

Energy delivered per second taking into account heat loss:

$\Delta Q/\Delta t = \text{Power output of heater} - \text{energy lost per second} = Q_{\text{in}} - Q_{\text{out}}$

$\Delta Q/\Delta t = 1700 - 600 = 1100 \text{ J s}^{-1}$

Time required to heat the substance by 10°C :

$t = Q_0 / (\Delta Q/\Delta t)$

$t = 71800 / 1100 = 65 \text{ s}$

[4]

Mark scheme guidance

Question 6(a)(i):

Need both parts for mark to be awarded.

Question 6(b)(i):

One mark for correct substitution.

Ignore unit.

Question 6(b)(ii):

One mark for correct substitution into equation. If T in Kelvin is used (283) this is XP and scores zero.

Question 6(b)(iii):

Award mark for evidence of correct method.

Unit required.

Allow ecf for incorrect value of Q calculated in part (ii).

Award up to two marks for using Power output from part (i) as $\Delta Q/\Delta t$ gives 42 s]

Examiners comments

Question 6(a) – Most candidates were aware that latent heat was involved with the changing state of a material but many omitted to include reference to constant temperature, so were not awarded the mark in part (i). Nearly all the candidates identified the correct section of the graph.

Question 6(b)(ii) – Parts (i) and (ii) were generally well answered and it was good to see most candidates using temperature change in part (ii) and not temperature in Kelvin. Part (iii) was challenging so it was good to see many candidates making attempts at the calculation which gained them some of the marks. Again, this is another question where candidates who show their working carefully are able to gain credit.



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