OCR
Oxford Cambridge and RSA

Cambridge Technicals
Engineering

Unit 2: Science for engineering

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

Mark Scheme for January 2019

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

Annotation	**Meaning**
tick	correct response worthy of a mark. **number of ticks = no of marks awarded**
cross	incorrect
omission (carat)	missing something
ecf	error carried forward
bod	benefit of doubt
nbod	not benefit of doubt
pot	power of ten error
con	contradiction
re	rounding error
sf	significant figure error
up	unit penalty

Subject specific marking instructions

In all numerical calculation questions a correct response to 2 sf will gain all marks unless specified otherwise. You do not need to see all the workings if the answer is correct.

<table>
<tr><th colspan="3">Question</th><th>Solution</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><td>Unit</td><td>Symbol</td><td>Physical Quantity</td></tr>
<tr><td>metre</td><td>m</td><td>length</td></tr>
<tr><td>Ampere</td><td>A</td><td>(electric) current</td></tr>
<tr><td>Kelvin</td><td>K</td><td>Temperature</td></tr>
<tr><td>Candela</td><td>cd</td><td>luminous intensity</td></tr>
</table>
</td><td>1
1
1</td><td>Bold words indicate what should be written in the table.
1 mark for each correct row.
NOT ‘amps’ in third column. Capital A only for unit.

Ignore spelling. NOT luminosity or light or intensity, but accept light intensity.</td></tr>
<tr><td>1</td><td>(b)</td><td></td><td>Diameter = 29.75 mm</td><td>1</td><td>NOT 29.7 or 29.8
Must be 4sf.</td></tr>
<tr><td>1</td><td>(c)</td><td>(i)</td><td>If answer = 0.25% award 2 marks.
Percentage error = absolute error/true value × 100% = (measured value-true value)/true value.
= (12.03-12.00/12.00) × 100 = 0.25%

Alternative method:
12.03 ÷ 12.00 (= 1.0025)
Percentage uncertainty = (1.0025 – 1) × 100 = 0.25%</td><td>1
1

(1)
(1)</td><td>Evidence of the use of correct equation (1), Evaluation (1).
Absolute error = 0.03 gains no marks.
Award one mark out of 2 for correct calculation of % uncertainty using any other measurement value given in the table.
Ignore sign of final answer.</td></tr>
<tr><td>1</td><td>(c)</td><td>(ii)</td><td>Mean value = (12.11+11.95+12.03+11.99+11.94)/5 (= 12.01 mm)</td><td>1</td><td>Evidence of working to gain mark.</td></tr>
</table>

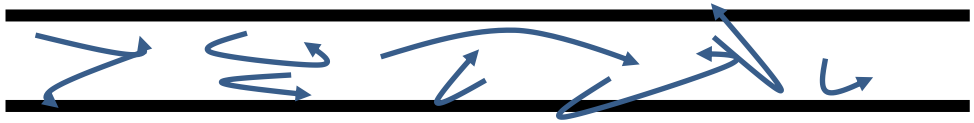
Question			Solution	Mark	Guidance
1	(c)	(iii)	**If standard deviation = 0.05657 award 3 marks.** Either: sd = $\sqrt{((\Sigma (x - \text{mean})^2)/N}$ $= \sqrt{((12.11-12.01)^2 + (11.95-12.01)^2 + (12.03-12.01)^2 + (11.99-12.01)^2 + (11.97-12.01)^2)/5)} = \sqrt{0.0032}$ $= 0.05657$ Or: sd = $\sqrt{((\Sigma x^2)/N - \text{mean}^2)}$ $= \sqrt{(12.11^2 + 11.95^2 + 12.03^2 + 11.99^2 + 11.97^2)/5 - 12.01^2)} = \sqrt{0.0032}$ $= = 0.05657$	1 1 1 (1) (1) (1)	First mark is for using the correct equation/method, ie writing the equation. Second mark for using correct value for mean and N to get value of 0.0032. Third mark for square root and 4sf. If answer given to a different number of sf but rounds to correct value – only 2 marks awarded. Award 2 marks for answer of 0.0032 (forget to square root). Award 2 marks for correct calculation with incorrect mean value (eg 12.00 or ecf from part (ii). Award max 2 marks for use of an incorrect integer value of N. If method is clear but there has been one transcription error, only lose 1 mark.
1			**Question total**	**10**	

Question			Solution	Marks	Guidance
2	(a)	(i)	PE = mgh = 1000 × 9.8 × 7 = 69000 J	1	Actual value using 9.8 is 68600. Actual value using 9.81 is 68670.
2	(a)	(ii)	All PE is converted into KE at point B so KE = 69000 J KE = ½ m v^2 = 69000 v = $(2 \times KE/m)^{0.5}$ = $(2 \times 690001000)^{0.5}$ = 11.7 m s^{-1} OR: using suvat equations a = g sin 30° and s = 7/sin30° (and u = 0) ($v^2 = u^2 + 2as$ so) v^2 = 2 (g sin 30°)(7/sin30°) = 137.2 so v = 11.7 m s^{-1}	 1 1 (1) (1)	Need to see correct working. Allow ecf from 2a(i) for first marking point. Answer should be to more than 2 sf to gain both marks as this is 'show that' question. Components: a = 4.9 and s = 14
2	(a)	(iii)	**If time = 4.1 s or 4.0 s award 3 marks.** a = -friction force ÷ mass = -2.94 ×1000 ÷ 1000 = -2.9 m s^{-2} Use of v = u + at, so t = (v – u)/a t = (0 – 12) ÷ -2.9 = 4.1 s. Alternative method: F = change of momentum ÷ time = (mv – mu) ÷ t 2.94 = (1000 × 12) ÷ t t = 4.1 s	 1 1 1 (1) (1) (1)	 Calculation of a. Correct equation given (any subject) Evaluation Correct equation Substitution of values Evaluation If v = 11.7 then t = 4.0 [for full marks]
2	(b)	(i)	Total displacement = 7 - 6 = 1 m	1	
2	(b)	(ii)	Total distance = (6 - -2) + (-2 - -5) + (5 + 7) = 8 + 3 + 12 = 23 m	1	
2	(b)	(iii)	(Displacement = 7− -5 =) 12 m v = displacement ÷ time = 12 ÷ 3 = 4 m s^{-1} [1 sf is acceptable]	1 1	Award one mark if you see 12 divided by 2, 4 or 7.
2			**Question total**	**10**	

Question			Solution	Marks	Guidance
3	(a)	(i)	efficiency = P_{out}/P_{in} to give $P_{in} = P_{out}/\eta = 1000/0.85$ P_{in} = 1200 W	1	Actual value 1176.47
3	(a)	(ii)	Use of W = P t Conversion of power 1.18 kW and time to 0.5 hours, so W = 1.18 × 0.5= 0.59 kWh	1 1	Accept any power figure multiplied by any time for first mark, eg 1000 × 30. Accept ecf of power value from (i). If power = 680W then W = 0.425, scores 2 marks with ecf.
3	(b)		Resistor at constant temperature = X Filament lamp = Z Diode = Y	1 1	1 mark for one correct answer 2 marks for all 3 correct
3	(c)	(i)	(R_{eq} = R1 + R2 = 3 + 2 =) 5Ω	1	
3	(c)	(ii)	(V = I R so I = V/R = 20/5 =) 4A	1	
3	(c)	(iii)	**If inductance = 0.25 or 250 award 2 marks.** **If inductance = 0.25 H or 250 mH award 3 marks.** L = N Φ ÷ I L = (100 × 10) ÷ 4 = 250 or L = (100 × 0.01) ÷ 4 = 0.25 0.25 **H** or 250 **mH**	 1 1 1	 Correct equation used. Allow ecf of current value from (ii). Unit consistent with POT. Accept Wb A^{-1}. If a candidate has not carried out the correct calculation but writes the correct unit for inductance (H) which is consistent with the value used for flux, ie if flux is in mWb then inductance should be in mH, the third mark can be awarded. Consistent unit mark.
3			**Question total**	**10**	

Question			Solution	Marks	Guidance
4	(a)		ANY 2 of: Either term is the material's ability to store energy. Resilience relates to elastic deformation. Toughness relates to plastic/permanent deformation.	1 + 1	Accept ability to spring back to shape.
4	(b)		ANY 2 of: Either term is the material's ability to deform plastically/permanently. Malleability is for compression/pushing forces Ductility is for tension/pulling/stretching.	1 +1	ALLOW bending, hammering but ignore moulding ALLOW drawing (into wires).
4	(c)	(i)	Area of rod = $\pi\ 13^2$ (= 530 mm^2 or 5.3×10^{-4} m^2) $\sigma = F/A = 18000 \div 530$ (= 34 MPa or 34×10^6 Pa) $\varepsilon = \Delta l / L = (24 \times 10^{-6}) \div (150 \times 10^{-3}) = 1.6 \times 10^{-4}$ $E = \sigma / \varepsilon = 34 \div (1.6 \times 10^{-4}) = 210000$ **MPa** = 210 **GPa** = 2.1×10^{11} **Pa** **If E = 210 GPa award 4 marks.**	1 1 1 1	Method of calculating area. Ignore POT. Method of calculating stress. Ignore POT. Calculation of strain with correct POT. Calculation of Young modulus with correct and consistent unit. Common errors: Using 26 mm as radius, gives $E = 5.3 \times 10^{10}$ Pa [max 3] Using 26 mm as area, gives $E = 4.3 \times 10^9$ Pa or $E = 4.3 \times 10^{12}$ Pa [max 2] Using 13 mm as area, give $E = 8.7 \times 4.3 \times 10^9$ Pa or $E = 8.7 \times 10^{12}$ Pa [max 2] Incorrect POT in final answer because wrong POT in either/both area and stress, eg 210000 Pa [max 3]. Incorrect working to calculate both stress and strain, but evidence that the values calculated are substituted into $E = \sigma / \varepsilon$ and have valid unit gains 1-mark max.

Question			Solution	Mark	Guidance
4	(c)	(ii)	**If extension = 0.26 mm or 0.25 award 2 marks.** Strain, $\varepsilon_{max} = \sigma_{max} / E = 350 \times 10^{6} \div (210 \times 10^{9}) = 1.7 \times 10^{-3}$ extension $= \varepsilon_{max} \times L = 1.7 \times 10^{-3} \times 150 = 0.26$ mm	1 1	Allow ecf for E calculated in part (i). Ignore POT error here. Penalise POT error in final value.
4			**Question total**	**10**	

Question			Solution	Marks	Guidance
5	(a)		ANY 2 of: Gases are compressible / liquids are incompressible; Gas volume will decrease / liquids have constant volume; Gas density will increase / liquid density is (roughly) constant.	1 + 1	
5	(b)		One mark for each diagram.  Laminar  Turbulent	1 1	Minimum 3 arrows for each diagram. Laminar flow – all lines with arrows should be parallel. Not dashed. Turbulent flow – haphazard lines with arrows. No arrows on either diagram which are otherwise correct only loses one mark. Similarly with dashed lines.
5	(c)	(i)	**If density = 1300 kg m^{-3} award 2 marks.** Volume = $0.075 \times 0.16 \times 0.125$ (= 1.5×10^{-3} m^3) Density = mass / volume = $2 / (1.5 \times 10^{-3}) = 1300$ kg m^{-3}	1 1	Ignore POT for volume calculation. Penalise POT error in final value.
5	(c)	(ii)	Sinks because the density of the cuboid is larger than the density of water (or reverse argument).	1	Must include reason. Allow ecf from incorrect value for density calculated in part i.
5	(c)	(iii)	**If upthrust = 14.7 N award 2 marks.** (upthrust = weight of volume of water displaced ==) $\rho_{water} \times V_{object} \times g$ $F = 1000 \times 1.5 \times 10^{-3} \times 9.8 = 14.7$ N	1 1	Evidence of correct equation or correct substitution for first mark. Allow ecf of incorrect volume from part (i).
5			**Question total**	**9**	

Question			Solution	Marks	Guidance
6	(a)	(i)	Energy input by fan, Q = P t (= 1.5 × 5 × 60 = 450 J) Conservation of energy: energy lost = initial energy + energy input – final energy = 1200 + 450 – 900 = 750 J	1 1	Accept Q = 1.5 × 5 for this mark.
6	(a)	(ii)	Volume of Helium = $\pi \times 0.12^2 \times 0.3$ (= 1.4×10^{-2} m^3 Mass of Helium = volume × density (= $1.4 \times 10^{-2} \times 0.16 = 2.2 \times 10^{-3}$ kg) Change of temperature (= energy lost ÷ m c = 750 ÷ ($2.2 \times 10^{-3} \times 5200$))= 66(.4)°C Final temperature = 70 – 66(.4) = 3.6 °C	1 1 1 1	 Allow ecf of energy lost from part i. Accept 4 °C
6	(a)	(iii)	New height of cylinder of gas = 0.12 m. Ratio of volume = 0.12 ÷ 0.3 = 0.4 OR: New volume = $\pi \times 0.12^2 \times 0.12$ (= 5.4×10^{-3} m^3) Ratio of pressure = 1/ratio of volume so Ratio of pressure = 1 ÷ 0.4 = 2.5 or 250 % OR Ratio of pressure = $1.4 \times 10^{-2} \div 5.4 \times 10^{-3}$ = 2.5 or 250%	1 1 1	 Allow ecf of new height = 0.18m. (170%) Allow ecf of incorrect volume calculated in part ii.
6	(b)		EITHER Fabric A because it has a higher heat capacity. So it stores more thermal energy and/or will cool down more slowly. OR: Fabric B because it has a lower heat capacity. So it takes less energy input to heat it up to a certain temperature and/or it will heat up more quickly.	 1 1 (1) (1)	One mark for a choice with a reason. Second mark for an explanation of heat capacity in context. Achieving the second marking point will gain both marks without reference to heat capacity) Ignore reference to combustion.
6			**Question total**	**11**	
			PAPER TOTAL	**60**	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553