



# **Cambridge Technicals Engineering**

## **Unit 2: Science for engineering**

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

## **Mark Scheme for January 2019**

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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.

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**Annotations**

<b>Annotation</b>	<b>Meaning</b>
tick	correct response worthy of a mark. <b>number of ticks = no of marks awarded</b>
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.

Question			Solution	Mark	Guidance															
1	(a)		<table border="1"> <thead> <tr> <th>Unit</th> <th>Symbol</th> <th>Physical Quantity</th> </tr> </thead> <tbody> <tr> <td>metre</td> <td>m</td> <td>length</td> </tr> <tr> <td>Ampere</td> <td><b>A</b></td> <td><b>(electric) current</b></td> </tr> <tr> <td><b>Kelvin</b></td> <td>K</td> <td><b>Temperature</b></td> </tr> <tr> <td><b>Candela</b></td> <td>cd</td> <td><b>luminous intensity</b></td> </tr> </tbody> </table>	Unit	Symbol	Physical Quantity	metre	m	length	Ampere	<b>A</b>	<b>(electric) current</b>	<b>Kelvin</b>	K	<b>Temperature</b>	<b>Candela</b>	cd	<b>luminous intensity</b>	1	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.
			Unit	Symbol	Physical Quantity															
			metre	m	length															
			Ampere	<b>A</b>	<b>(electric) current</b>															
			<b>Kelvin</b>	K	<b>Temperature</b>															
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1																				
1	(b)		Diameter = 29.75 mm	1	NOT 29.7 or 29.8 Must be 4sf.															
1	(c)	(i)	<b>If answer = 0.25% award 2 marks.</b> Percentage error = absolute error/true value $\times$ 100% = (measured value-true value)/true value. = $(12.03-12.00/12.00) \times 100 = 0.25\%$  Alternative method: $12.03 \div 12.00 (= 1.0025)$ Percentage uncertainty = $(1.0025 - 1) \times 100 = 0.25\%$	1 1 (1) (1)	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.															
1	(c)	(ii)	Mean value = $(12.11+11.95+12.03+11.99+11.94)/5 (= 12.01 \text{ mm})$	1	Evidence of working to gain mark.															

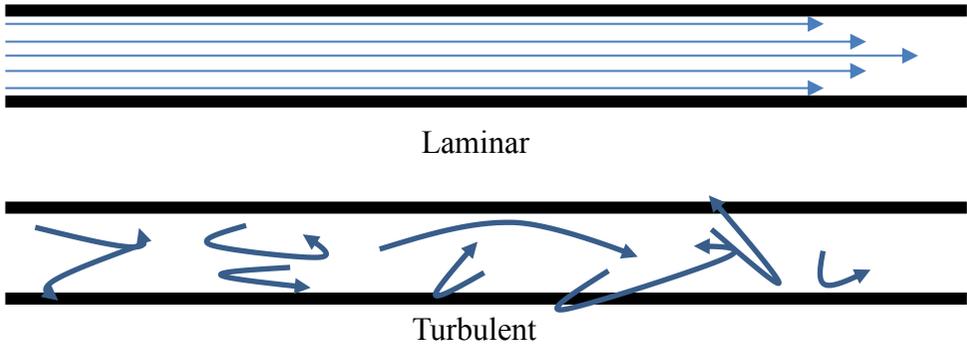
Question			Solution	Mark	Guidance
1	(c)	(iii)	<p><b>If standard deviation = 0.05657 award 3 marks.</b></p> <p>Either:</p> $sd = \sqrt{(\sum (x - \text{mean})^2)/N}$ $= \sqrt{((12.11-12.01)^2 + (11.95-12.01)^2 + (12.03-12.01)^2 + (11.99-12.01)^2 + (11.97-12.01)^2)/5} = \sqrt{0.0032}$ $= 0.05657$ <p>Or: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

Question			Solution	Marks	Guidance
2	(a)	(i)	$PE = mgh = 1000 \times 9.8 \times 7 = 69000 \text{ J}$	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 $KE = 69000 \text{ J}$ $KE = \frac{1}{2} m v^2 = 69000$ $v = (2 \times KE/m)^{0.5} = (2 \times 69000/1000)^{0.5} = 11.7 \text{ m s}^{-1}$  OR: using suvat equations $a = g \sin 30^\circ$ and $s = 7/\sin 30^\circ$ (and $u = 0$ ) $(v^2 = u^2 + 2as \text{ so}) v^2 = 2 (g \sin 30^\circ)(7/\sin 30^\circ) = 137.2$ so $v = 11.7 \text{ m s}^{-1}$	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)	<b>If time = 4.1 s or 4.0 s award 3 marks.</b> $a = \text{-friction force} \div \text{mass} = -2.94 \times 1000 \div 1000 = -2.9 \text{ m s}^{-2}$ Use of $v = u + at$ , so $t = (v - u)/a$ $t = (0 - 12) \div -2.9 = 4.1 \text{ s}$ . Alternative method: $F = \text{change of momentum} \div \text{time} = (mv - mu) \div t$ $2.94 = (1000 \times 12) \div t$ $t = 4.1 \text{ s}$	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 = $7 - 6 = 1 \text{ m}$	1	
2	(b)	(ii)	Total distance = $(6 - -2) + (-2 - -5) + (5 + 7) = 8 + 3 + 12 = 23 \text{ m}$	1	
2	(b)	(iii)	(Displacement = $7 - -5 = 12 \text{ m}$ ) $v = \text{displacement} \div \text{time} = 12 \div 3 = 4 \text{ m s}^{-1}$ [1 sf is acceptable]	1 1	Award one mark if you see 12 divided by 2, 4 or 7.
2			<b>Question total</b>	<b>10</b>	

Question		Solution		Marks	Guidance
3	(a)	(i)	efficiency = $P_{out}/P_{in}$ to give $P_{in} = P_{out}/\eta = 1000/0.85$ $P_{in} = 1200 \text{ W}$	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 $W = 1.18 \times 0.5 = 0.59 \text{ kWh}$	1  1	Accept any power figure multiplied by any time for first mark, eg $1000 \times 30$ . 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)	( $R_{eq} = R1 + R2 = 3 + 2 =$ ) $5\Omega$	1	
3	(c)	(ii)	( $V = I R$ so $I = V/R = 20/5 =$ ) 4A	1	
3	(c)	(iii)	<b>If inductance = 0.25 or 250 award 2 marks.</b> <b>If inductance = 0.25 H or 250 mH award 3 marks.</b> $L = N \Phi \div I$ $L = (100 \times 10) \div 4 = 250$ or $L = (100 \times 0.01) \div 4 = 0.25$ <b>0.25 <u>H</u> or 250 <u>mH</u></b>	1 1 1	Correct equation used. Allow ecf of current value from (ii). Unit consistent with POT. Accept $\text{Wb A}^{-1}$ . 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			<b>Question total</b>	<b>10</b>	

Question		Solution	Marks	Guidance
4	(a)	<p>ANY 2 of:            Either term is the material's ability to store energy.            Resilience relates to elastic deformation.            Toughness relates to plastic/permanent deformation.</p>	1 + 1	Accept ability to spring back to shape.
4	(b)	<p>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.</p>	1 + 1	<p>ALLOW bending, hammering but ignore moulding            ALLOW drawing (into wires).</p>
4	(c)	<p>(i) Area of rod = <math>\pi 13^2</math> (= 530 mm<sup>2</sup> or <math>5.3 \times 10^{-4}</math> m<sup>2</sup>)  <math>\sigma = F/A = 18000 \div 530</math> (= 34 MPa or <math>34 \times 10^6</math> Pa)  <math>\epsilon = \Delta l / L = (24 \times 10^{-6}) \div (150 \times 10^{-3}) = 1.6 \times 10^{-4}</math>  <math>E = \sigma / \epsilon = 34 \div (1.6 \times 10^{-4}) = 210000 \text{ MPa} = 210 \text{ GPa} = 2.1 \times 10^{11} \text{ Pa}</math></p> <p><b>If E = 210 GPa award 4 marks.</b></p>	<p>1            1            1            1</p>	<p>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 <math>E = 5.3 \times 10^{10}</math> Pa [max 3]            Using 26 mm as area, gives <math>E = 4.3 \times 10^9</math> Pa or <math>E = 4.3 \times 10^{12}</math> Pa [max 2]            Using 13 mm as area, give <math>E = 8.7 \times 4.3 \times 10^9</math> Pa or <math>E = 8.7 \times 10^{12}</math> 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 <math>E = \sigma / \epsilon</math> and have valid unit gains 1-mark max.</p>

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

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. 	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) <b>If density = 1300 kg m<sup>-3</sup> award 2 marks.</b> Volume = 0.075 × 0.16 × 0.125 (= 1.5 × 10 <sup>-3</sup> m <sup>3</sup> ) Density = mass / volume = 2 / (1.5 × 10 <sup>-3</sup> ) = 1300 kg m <sup>-3</sup>	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) <b>If upthrust = 14.7 N award 2 marks.</b> (upthrust = weight of volume of water displaced ==) $\rho_{\text{water}} \times V_{\text{object}} \times g$ $F = 1000 \times 1.5 \times 10^{-3} \times 9.8 = 14.7 \text{ N}$	1 1	Evidence of correct equation or correct substitution for first mark. Allow ecf of incorrect volume from part (i).
5		<b>Question total</b>	<b>9</b>	

Question			Solution	Marks	Guidance
6	(a)	(i)	Energy input by fan, $Q = P t (= 1.5 \times 5 \times 60 = 450 \text{ J})$ Conservation of energy: energy lost = initial energy + energy input – final energy = $1200 + 450 - 900 = 750 \text{ J}$	1 1	Accept $Q = 1.5 \times 5$ for this mark.
		(ii)	Volume of Helium = $\pi \times 0.12^2 \times 0.3 (= 1.4 \times 10^{-2} \text{ m}^3)$ Mass of Helium = volume $\times$ density ( $= 1.4 \times 10^{-2} \times 0.16 = 2.2 \times 10^{-3} \text{ kg}$ ) Change of temperature ( $= \text{energy lost} \div m c = 750 \div (2.2 \times 10^{-3} \times 5200) = 66(.4)^\circ\text{C}$ ) Final temperature = $70 - 66(.4) = 3.6^\circ\text{C}$	1 1 1 1	Allow ecf of energy lost from part i. Accept $4^\circ\text{C}$
6	(a)	(iii)	New height of cylinder of gas = 0.12 m.  Ratio of volume = $0.12 \div 0.3 = 0.4$ OR: New volume = $\pi \times 0.12^2 \times 0.12 (= 5.4 \times 10^{-3} \text{ m}^3)$  Ratio of pressure = 1/ratio of volume so Ratio of pressure = $1 \div 0.4 = 2.5$ 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.
		(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			<b>Question total</b>	<b>11</b>	
			<b>PAPER TOTAL</b>	<b>60</b>	

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