Cambridge Technicals
Engineering

Unit 2: Science for engineering

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

Mark Scheme for June 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.

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

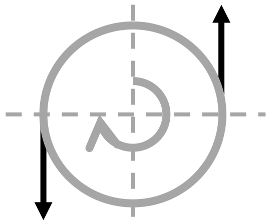
Subject specific marking instructions

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>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><td></td><td colspan="2">Precision</td></tr>
<tr><td>System</td><td>Precise</td><td>Imprecise</td></tr>
<tr><td>A</td><td>✓</td><td></td></tr>
<tr><td>B</td><td>✓</td><td></td></tr>
<tr><td>C</td><td></td><td>✓</td></tr>
</table>
</td><td>3</td><td>1 mark for each correct row.</td></tr>
<tr><td>1</td><td>(b)</td><td></td><td>One mark for each:

1 metre is equal to 10^{3} mm
1 gram is equal to 10^{-6} Mg
1 litre is equal to 10^{6} mm^{3}</td><td>3</td><td>1 mark for each correct answer.
ALLOW
1000 for 10^{3}
0.000001 for 10^{-6}
1000000 for 10^{6}.

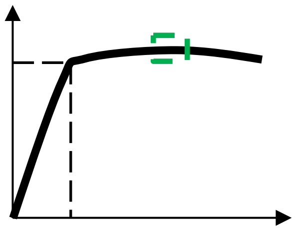
Special case:
• If a candidate has all 3 correct number but all have the wrong sign – award 1 mark.</td></tr>
<tr><td>1</td><td></td><td></td><td>Question total</td><td>6</td><td></td></tr>
</table>

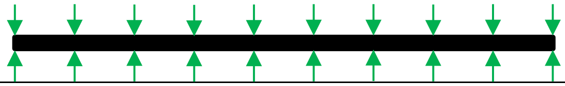
Question			Answer	Marks	Guidance
2	(a)	(i)	Couple = Torque ÷ Perpendicular distance between two forces OR = 120 ÷ 40 = 120 ÷ (40 x 10^{-3}) = 3.0 x10^3 N or 3 kN	 1 1	**If answer = 3000 N award 2 marks.** Stating correct equation. If no (or incorrect) conversion from mm to m (3N), award 1 mark out of 2. If radius used instead of diameter (6000N), award 1 mark out of 2. Accept 1sf here.
2	(a)	(ii)	**A pair of** arrows applied tangentially at either end of a diameter.  **Correct** direction on arrow(s) (anticlockwise).	1 1	There must be 2 arrows which are parallel (by eye), same length (by eye) and tangential (touching) the bar for this mark to be awarded. Accept a diameter at any angle. This is an independent mark which can be awarded for any arrowhead (causing anticlockwise motion) shown anywhere on the diagram.
2	(b)	(i)	EITHER: Force in string $F_B = \sqrt{(F_A^2 + W^2)}$ OR $= \sqrt{(4^2 + 3^2)}$ $= \sqrt{(16 + 9)} = 5$ kN OR Drawing (scale) diagram of vector triangle with a ruler. Correct final value for force between 4.9 and 5.1 kN.	 1 1 (1) (1)	**If answer = 5 kN award 2 marks.** Use of correct equation. ALLOW $4^2 + 3^2$ OR 16 +9 for 1 mark. Arrows not needed

Question			Answer	Marks	Guidance
2	(b)	(ii)	cos $\alpha = F_A \div F_B = 4 \div 5$ OR sin $\alpha = W \div F_B = 3 \div 5$ OR tan $\alpha = W \div F_A = 3 \div 4$, so $\alpha = 37°$	1	Allow ecf from 2(b)(i). If measured from scale diagram accept α in range 30° to 40°.
2	(c)	(i)	A horizontal line across at least as far as t = 3s. at v = -2 m s^{-1}	1 1	By eye.
2	(c)	(ii)	Acceleration = 0 ms^{-2} **because** (one of the following or wtte) • the velocity is constant • the velocity vs time graph has a zero gradient • the position vs time graph is a straight line .	1	ALLOW acceleration is the gradient of velocity-time graph or the rate of change of velocity. ALLOW ecf for a calculation of the gradient of their straight line drawn in part (i).
2	(c)	(iii)	(Work done) = Force x distance travelled OR = (5 x 10^3) x 6 = 3.0 x 10^4 **<u>J</u>** or 30 **<u>kJ</u>**	1 1	**If answer = 30 kJ or 3 x 10^4 J award 2 marks.** Evidence of use of correct equation. A value of 30 or 30,000 with no working is evidence of 5 × 6. Value must include **consistent unit.** Allow dimensionally correct alternative units.
2			**Question total**	**12**	

Question			Answer	Marks	Guidance
3	(a)	(i)	Resistance in parallel section: $\frac{1}{R} = \frac{1}{23} + \frac{1}{22}$ (R calculated correctly as) 11.2 or $\frac{1}{0.089}$ or $\frac{506}{45}$ or equivalent fraction $R_T = 11(.2) + 9 = 20\ (.2)$	1 1 1	**Working must** be shown this s a **show that** question. A correct algebraic/numeric expression with a clear subject and the final answer to at least 3sf will gain 3 marks. Just seeing. $\frac{1}{23} + \frac{1}{22} = \frac{45}{506}$, does not gain the first marking point. Accept reverse argument clearly explained.
3	(a)	(ii)	(I =) V÷R OR = 12÷20 OR 12÷20.2 = 0.60 or 0.59 A	1 1	**If answer = 0.6 A award 2 marks.** Rearranged equation or correct substitution [12 = I × 20(.2)] No ecf from part (i) (unless R rounds to 20) Accept 1 sf.
3	(b)	(i)	**EITHER:** (Energy stored) = ½ C V^2 OR = 0.5 x 12 x 10^{-3} x 9^2 = 0.49 J OR (Q = CV) =12 (x 10^{-3}) × 9 = (108 (x 10^{-3}) or 110 (x 10^{-3})) (W) = ½ × 108 x 10^{-3}× 9 = 0.49 (or 0.50) J	1 1 (1) (1)	**If answer = 0.49 J award 2 marks.** **Quoting or using** correct equation. If no (or incorrect) conversion from mF to F, answer will be 490 J second mark lost.
3	(b)	(ii)	τ = RC OR = 20 x 12 (x 10^{-3}) = 0.24s = 0.24 s	1 1 1	**If answer = 0.24 s award 2 marks.** **Quoting** correct equation. Correct POT. Only penalise this POT error once in question. Allow ecf for incorrect POT already penalised in (i).

Question			Answer	Marks	Guidance
3	(b)	(iii)	$V = V_0\, e^{(-t/RC)} = 9\ e^{(-0.4/0.24)}$ $= 1.7$ V	1 1	**If answer = 1.7 V award 2 marks.** Substituting values into correct equation. Ignore minus sign for substitution mark (about 48). Allow ecf of incorrect value for RC from part (ii).
3			**Question total**	**11**	

Question			Answer	Marks	Guidance
4	(a)	(i)	(Young's modulus) = gradient (of elastic region) of stress-strain curve OR stress÷strain OR = 140÷0.002 = 70,000 MPa	1 1	**If answer = 70,000 MPa award 2 marks.** se of correct equation. Accept 1 sf. Penalise POT error in final answer.
4	(a)	(ii)	Point marked at highest point of curve. 	1	Accept point anywhere within box shown on diagram, or on the corresponding position on the stress axis.
4	(a)	(iii)	<u>Elastic</u> and <u>Plastic</u> (deformation). Elastic deformation is reversible / plastic deformation is permanent; Any 2 of: Elastic deformation – bonds between atoms are stretched (under load); Elastic deformation – atoms return to original position when load removed; Plastic deformation – planes/rows of atoms slide over one another; Plastic deformation – dislocations move, slip occurs (through the structure) Plastic deformation – necking occurs. [wtte]	1 1 2	Both needed for mark. Either or both statement(s) scores **one** mark. Ignore reference to failure of material.
4	(b)		First box ticked.	1	
4	(c)		Repeated vibration: Endurance Resistance to scratches and abrasions: Hardness	1 1	Accept fatigue strength not durability.
4			**Question total**	**10**	

Question			Answer	Marks	Guidance
5	(a)		Viscosity is a fluid's ability to resist shear forces	1	
5	(b)	(i)	Arrows towards plate surface(s) at right angles (minimum 3 arrows); Evenly distributed arrows towards plate (by eye) across both (top and bottom) surfaces. 	1 1	This mark can be awarded if only one surface is used. A minimum of 3 arrows on each of top and bottom surface are required to assess even distribution.
5	(b)	(ii)	(Pressure) = ρ_w g h OR = 790 x 9.8 x 5 OR = 3.9 x 10^4 Pa (F = PA) = 3.9 x 10^4 x 15 (F) = 5.8 x 10^5 N	1 1 1	**If answer = 5.8 x 10^5 N award 3 marks.** Calculating pressure.
5	(b)	(iii)	(Absolute pressure) = gauge pressure + atmospheric pressure OR 3.9 x 10^4 + 101 (x 10^3) =((790 x 9.8 x 5) + (101 x 10^3))= 1.4 x 10^5 Pa	1 1	**If answer = = 1.4 x 10^5 Pa award 2 marks.** Evidence of use of correct equation Allow ecf from incorrect pressure calculated in part (ii).
5	(b)	(iv)	Upthrust = weight of the volume displaced OR Upthrust = density x volume x acceleration of gravity OR 22(x 10^3)= 790 × V ×9.8) Volume (= (22 x 10^3) ÷ (790 x 9.8))= 2.84 (m^3) Thickness (= volume ÷ area) = 2.84 ÷ 15 = 0.19 **m** OR 19 **cm**	1 1 1 1	**If answer = 0.19 m award 4 marks.** Stating or using correct equation. Calculation of volume (ignore POT here) Must include consistent unit (somewhere on the page).
5			**Question total**	**12**	

Question			Answer	Marks	Guidance
6	(a)	(i)	Using combined gas law equation: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ OR $\frac{PV}{T}$ = constant Substitution of correct values: $\frac{250 \times 0.13}{300} = \frac{P_2 \times 0.07}{305}$ P_2 = 470 kPa	1 1 1	**If answer = 470 kPa award 3 marks.** 250 × either volume ÷ either temperature (K or °C) will get the first mark. Ignore POT in substitution mark.
6	(a)	(ii)	State or use ideal gas law pV = nRT Substitution of correct set of values: 250 × 0.13 = n × R × 300 OR 470 × 0.07 = n × R × 305 n = 13 mol	1 1 1	**If answer = 13 mol award 3 marks.** Allow temp in °C for first mark. Allow ecf of incorrect P_2 from part (i) POT error will lose one mark here.
6	(b)	(i)	(The internal energy of a system is) the <u>sum/total</u> of the (random distribution); of <u>kinetic and potential</u> energy of the <u>molecules/particles/atoms</u> inside a system.	1 1	Need to see the idea of sum or total. Allow definitions of kinetic and potential energy eg, energy stored in bonds (potential), movement energy (kinetic).
6	(b)	(ii)	(Absolute zero is the temperature) when all substances have minimum (internal) energy.	1	ALLOW zero energy. ALLOW particles have no/least movement/kinetic energy.
6			**Question total**	**9**	
			PAPER TOTAL	**60**	

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