

Cambridge Technicals Engineering

Unit 2: Science for engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825 & 05873

Mark Scheme for June 2022

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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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MARKING INSTRUCTIONS

PREPARATION FOR MARKING

TRADITIONAL

Before the Standardisation meeting you must mark at least 10 scripts from several centres. For this preliminary marking you should use **pencil** and follow the **mark scheme**. Bring these **marked scripts** to the meeting.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the traditional 40% Batch 1 and 100% Batch 2 deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or by email.
5. **Crossed Out Responses**
Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of questions across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. (The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)

Multiple Choice Question Responses

When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. (The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)

Short Answer Questions (requiring a more developed response, worth **two or more marks**)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)

Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional lined pages if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add an annotation to confirm that the work has been seen.
7. **No Response** (NR) option. Award 0 marks and indicate using a red mark in the answer space:
 - If there is nothing written at all in the answer space
 - OR if there is a comment which does not in anyway relate to the question (e.g. 'can't do', 'don't know')
 - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the questionNote: Award 0 marks - for an attempt that earns no credit (including copying out the question)
8. Assistant Examiners will email a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking period. Your report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

9. Annotations

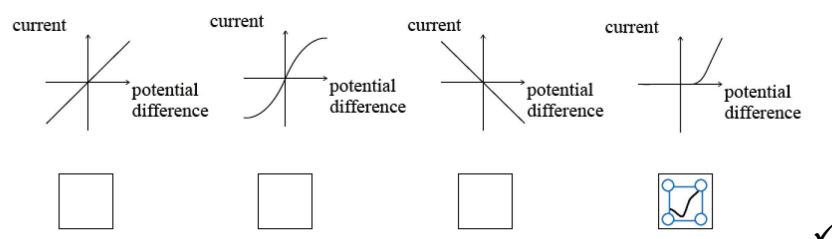
Annotation	Meaning
tick	correct response worthy of a mark. number of ticks = no of marks awarded
cross	incorrect
omission (carat)	missing something
ecf	error carried forward
bod	benefit of doubt
nbod	not benefit of doubt
pot	power of ten error
con	contradiction
re	rounding error
sf	significant figure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

10. Subject specific marking instructions

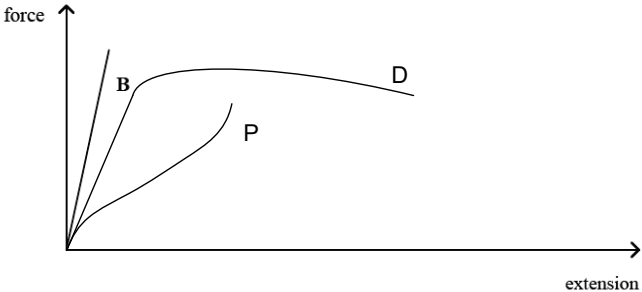
In all numerical calculation questions, a correct response to 2 sf will gain all marks unless specified otherwise. You do not need to see all the workings if the answer is correct.
Power of ten errors in otherwise correct calculations will be penalised -1 mark unless otherwise specified.

Question			Solution	Marks	Guidance
1	(a)	(i)	kilogram ✓	1	ALLOW symbol kg (all lowercase). DO NOT ALLOW kilos.
		(ii)	Kelvin ✓	1	ALLOW symbol, capital K
		(iii)	mole ✓	1	ALLOW symbol, mol
	(b)	(i)	inaccurate ✓	1	ALLOW circle/underline or written on dotted line. Don't allow contradiction.
		(ii)	Apply a -0.1 A absolute correction <input checked="" type="checkbox"/> Apply a $+0.1$ A absolute correction <input type="checkbox"/> Apply a -0.1 A relative correction <input type="checkbox"/> Apply a $+0.1$ A relative correction <input type="checkbox"/>	1	Tick in the top box.
	(c)		measurements/quantities/readings will have differing values or within in a range ✓ either side of the accepted or true value ✓	2	ALLOW how far the measured value is to the true value for 1 mark. IGNORE references to the minimum division on measuring equipment.
1			TOTAL	7	

Question		Solution	Marks	Guidance
2	(a) (i)	Arrow pointing vertically (by eye) upwards ✓ Same length as printed W arrow (by eye) ✓	2	Accept arrow anywhere on diagram. DO NOT ALLOW 2 nd marking point unless arrow is vertically upwards.
	(a) (ii)	(for a system) in equilibrium there is no <u>resultant/net</u> force AND/OR no <u>resultant/net</u> torque/moment ora ✓ ANY 1 from: rotation means that the wheel is accelerating ✓ there is a torque / moment / couple acting on the wheel ✓ the wheel must have more weight/force on one side than the other (ora) OR moments are not equal ✓	2	IGNORE balanced or equal forces IGNORE moving. .
	(a) (iii)	X marked anywhere on the left side of the wheel ✓	1	Accept anywhere on left side of diagram.
	(b)	Straight line from the origin with positive gradient ✓ Line meets (20, 200) ✓ Line horizontal from $t = 20$ to $t = 30$ ✓	3	Not if the horizontal line begins below $t = 20$.
	(c)	$(E = 0.5 \times m \times v^2) = 0.5 \times 500 \times 10^2$ ✓ $= 25000$ ✓ J or Joule ✓	3	First mark is for correct substitution into equation. Using an incorrect equation will gain no marks. Special case: allow this mark for correct equation written down, but candidate then does not square velocity. The unit mark is an independent marking point. ALLOW dimensionally correct units eg $\text{kg m}^2 \text{s}^{-2}$. ALLOW final answer to correct POT with consistent unit, eg 25 kJ for full marks. Watch out here for candidates using incorrect equations eg $\frac{1}{2}mv$, which give an answer which looks like a POT error [0].
2		TOTAL	11	

Question		Solution	Marks	Guidance
3	(a)	positive to negative. ✓	1	ALLOW circle/underline or written on dotted line.
	(b)	ANY 2 from: Current will be lower in semi-conductor / higher in metal ✓ Semi-conductor has higher resistivity / metal has higher conductivity (ORA) ✓ Metals have <u>only</u> negative charge carriers or electrons ✓ Semi-conductor could have either negative or positive charge carriers (electrons and holes) ✓ Semi-conductor has fewer mobile charge carriers / metals have more mobile charge carriers.	2	ALLOW slower / faster current ALLOW metals are better conductors than semi-conductors owtte. NOT some metals are poor conductors (CON). ALLOW resistance and conductance instead of resistivity and conductivity. IGNORE references to insulation. IGNORE semiconductor has charge flowing from negative to positive. ALLOW reference to number density
	(c) (i)	$(R = V \div I) = 3.0 \div 0.15$ ✓ $= 20$ ✓ Ω (ohm) ✓	3	First mark is for correct substitution into equation. Using an incorrect equation does not get either of the first two marks. The unit mark is an independent marking point.
	(c) (ii)		1	Fourth graph ticked

Question		Solution	Marks	Guidance
(d)	(i)	$(L = N\Phi \div I) = 50 \times 1.2 \div 150 \checkmark$ $L = 0.4 \checkmark$ ANY 1 of the following (seen or implied). \checkmark converting both 150 mA to A <u>and</u> 1.2mWb to Wb OR leaving both 150 mA and 1.2 mWb as they are, cancelling 10^{-3} . OR leaving 1.2mWb and converting 150mA will give final value in mH. $L = 400 \text{ mH} \checkmark$	4	First mark is for correct substitution into equation ignoring POT. If 150(mA) and 1.2×10^{-3} used answer = 4×10^{-4} (kH) If 150×10^{-3} and 1.2 (mWb); answer = 400 (mH) If candidate uses a second equation, eg $W = \frac{1}{2}LI^2$, with previously calculated value of L – max 3 marks if L = 0.4 and if L has a POT error -max 2 marks.
(d)	(ii)	$P = E \div t = 0.075 \div 25 \checkmark$ $25 \text{ ms} = 25 \times 10^{-3} \text{ s} \checkmark$ $(P = 3)$	2	This is a ‘show that’ question so for the first mark the equation (any subject) should be seen in either conventional symbol form (energy could be E , W , U or Q) or in words AND 2 values substituted. ALLOW reverse argument. ie, substituting values for P and E to find $t = 0.025 \text{ s}$, or P and t to find E. Second mark is for evidence of correct conversion of ms to s.
3		TOTAL	13	

Question		Solution	Marks	Guidance
4	(a) (i)	Force per unit area OR Force divided by area. ✓	1	ALLOW F/A , force over area NOT force applied to an area DO NOT ALLOW units eg Newtons per metre squared. IGNORE surface IGNORE pressure .
	(a) (ii)	pascal OR Pa ✓	1	ALLOW Nm^{-2} , Nmm^{-2} , or MNm^{-2}
	(b)	ceramic material / glass / cast iron / slate ✓	1	eg, porcelain, china, brick, (hardened) clay, cement ALLOW named brittle polymer eg, Perspex (PMMA) or polystyrene. IGNORE examples of products made from brittle materials, eg tile, window etc. NOT wood or paper
	(c) (i)	Initial <u>straight line</u> labelled D (from the origin) with positive gradient ✓ (Extended with) non-linear section of low(er) gradient which should be at least $2\times$ the extension of the straight-line portion. ✓ 	2	Straight section of line must be at least 2cm (by eye). ALLOW non linear section to show a yield peak ie a maximum and then showing a small decrease in force as extension increases. If there is no linear section, then the low gradient non-linear line must cover over half the width of the graph. If lines are not labelled on graph, marks cannot be awarded for either (i) or (ii). If only one line is labelled, assume the other drawn line is the other part to question.

Question		Solution	Marks	Guidance
	(c) (ii)	A <u>curved line</u> labelled P with varying positive gradient. ✓ Gradient decreases and then increases as extension increases. ✓	2	NOT a straight line. DO NOT ALLOW negative gradient
	(d)	(atoms) move closer or return ✓ to <u>equilibrium</u> position ✓	2	
	(e)	ANY 2 from: Elastic deformation is the stretching of (inter-particle) bonds ✓ Plastic deformation is planes/sheets of particles sliding/slipping over one another. ✓ In plastic deformation bonds are broken and re-formed with different atoms. ✓ elastic deformation is reversible or plastic deformation is permanent (wtte) ✓ when the force is removed ✓	2	This last phrase only gets a mark when combined with previous statement,
4		TOTAL	11	

Question		Solution	Marks	Guidance
5	(a)	Solid ✓	1	Bottom box
	(b)	(i) Arrow pointing towards ball ✓ Horizontal (perpendicular to surface) to the left ✓	2	NOT tangential to the surface of the ball. ALLOW if a horizontal arrow pointing to the left anywhere on the diagram. IGNORE any pressure arrow drawn pointing towards the ball at any other point than X.
	(b)	(ii) absolute pressure = atmospheric pressure – gauge pressure. <input type="checkbox"/> absolute pressure = gauge pressure + atmospheric pressure. <input checked="" type="checkbox"/> absolute pressure = gauge pressure – atmospheric pressure. <input type="checkbox"/>	1	Middle box ticked
	(b)	(iii) ($P = h\rho g =$) $2.0 \times 1020 \times 9.8$ ✓ $= 20000 \text{ Pa}$ ✓	2	First mark is for correct substitution into equation. Using an incorrect equation will gain no marks. POT error in final mark -1. Actual value is 19992 but answer is acceptable to 2sf. ALLOW 2×10^4 for both marks.
	(b)	(iv) more than ✓	1	ALLOW circle/underline or written on dotted line.
	(c)	ANY 2 from: Upthrust is a force on an object (immersed) in a fluid. due to Archimedes' principle. Upthrust is equal (in magnitude) to the weight of fluid displaced. In the opposite direction to weight or upwards (possibly on a labelled diagram). larger upthrust from higher density fluids ora Upthrust causes buoyancy / prevents object from sinking If upthrust is larger than weight OR if the object is less dense than the fluid, there will be an upwards acceleration ora	2	Stating the equation $U_{\text{p thrust}} = \text{volume} \times \text{acceleration of gravity} \times \text{density of fluid}$ does not credit any marks as this can be copied from the formula booklet.
5		TOTAL	9	

Question			Solution	Marks	Guidance
6	(a)	(i)	By heating or thermally (from the natural gas burner) ✓	1	
	(a)	(ii)	By heating or thermally (to water in the radiators or the surroundings) ✓ Mechanically or kinetically (by moving the piston or driving the generator) ✓	2	ALLOW by movement by or work done of the piston IGNORE by moving the displacer
	(a)	(iii)	Choosing the non-flow equation: $Q = (U_2 - U_1) + W$ OR $U_1 + Q = U_2 + W$ ✓ {Energy entering = energy leaving} $Q = W$ so $U_2 - U_1$ (or change in internal energy) = 0 ✓	2	NOT steady flow equation, $Q = (W_2 - W_1) + W$. NOT U_1 = input energy AND/OR U_2 = output energy. U refers to internal energy in this case. IGNORE U_1 or $U_2 = 0$
	(b)	(i)	$P = mRT \div V$ ✓ $= 1.2 \times 2.08 \times 453 \div 0.006$ ✓ $= 1.9 \times 10^5$ Pa (188 kPa) ✓	3	Choice of correct equation. Correct substitution POT error -1.
	(b)	(ii)	$T = 453 - 273 = 180$ (°C) ✓	1	Correct value for absolute zero must be given to at least 3sf (ie allow more precise value than 273). DO NOT ALLOW final answer of 180 if candidate has used an incorrect value for absolute zero and rounded to 2 sf.
6			TOTAL	9	

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