Cambridge Technicals
Engineering

Unit 2: Science for engineering

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

Mark Scheme for January 2024

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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.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

   YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 RM Assessor 50% and 100% 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 using RM Assessor messaging.

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.

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. Award No Response (NR) if:
   - there is nothing written in the answer space or on associated diagram.

   Award Zero '0' if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses.
Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. 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.

10. **Annotations**

Annotation	Meaning
	correct response worthy of a mark. **number of ticks = no of marks awarded**
	incorrect
	missing something
	error carried forward
	benefit of doubt
	benefit of doubt not given
	power of ten error
	contradiction
	rounding error
	significant figure error
	to indicate that a blank page or space has been seen
BP	blank page

Mark Scheme abbreviations

Wtte: words to that effect

11. **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.

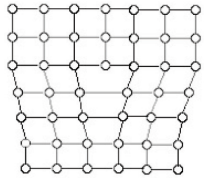
Most marking points are independently marked.
An exception to this is in 4(a).

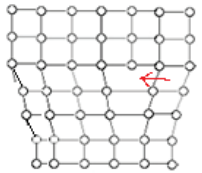
Question			Answer	Marks	Guidance
1	(a)		1.6 ✓	1	
	(b)	(i)	Pascal(s) OR Pa ✓	1	**DO NOT ALLOW** dimensionally equivalent alternatives here.
		(ii)	Stress ✓	1	2nd box ticked. Accept any clear indication of correct answer.
		(iii)	absolute pressure – atmospheric pressure ✓	1	2nd box ticked. Accept any clear indication of correct answer.
	(c)	(i)	[Absolute correction = true value – indicated value = 1.4 −1.2] = +0.20 (g) ✓	1	No marks for use of equation. **NOT** −0.20. **ALLOW** answer to 1 sf. (0.2 or .2)
		(ii)	Relative error $= \frac{\text{indicated value} - \text{true value}}{\text{true value}} = \frac{1.2-1.4}{1.4} = \frac{-0.20}{1.4}$ ✓ **= −**0.14 ✓	2	If final answer has incorrect sign, award 1 mark. If a candidate has clearly indicated that true value = 1, either here or in their answer to part (i) [-0.2] mark with ECF. Relative error $= \frac{\text{indicated value} - \text{true value}}{\text{true value}} = \frac{1.2-1}{1} = \frac{0.20}{1}$ ✓ = 0.2 ✓ Either 1 or 1.4 should be the denominator in the calculation for marks to be awarded. **IGNORE** any given units. **ALLOW** answer given to fraction in <u>simplest</u> form ie -1/7 or a percentage (-14%). **ALLOW** final answer to more than 2 sf.
1			**TOTAL**	7	

Question			Answer	Marks	Guidance
2	(a)	(i)	Evidence of substitution of work done and a value of time into correct equation. [$P = W \div t$] = 360 ÷ (2 × 60) ✓ = 3.0 (MW) ✓	2	For substitution mark: • **ALLOW** time = 2 (final answer = 180). • **IGNORE** POT of value of energy. **ALLOW** answer given to 1 sf here.
		(ii)	kg m s^{-1} kg m^2 s^{-2} kg m s^{-2} (kg m^2 s^{-3}) ✓	1	Last combination of base units circled. **ALLOW** any clear indication of correct answer.
		(iii)	(Scalar quantities) have magnitude ✓ not direction ✓	2	**ALLOW** size instead of magnitude. **ALLOW** second mark if candidate has said that scalar quantities have only magnitude. If a candidate has put magnitude and direction they can still get the first marking point.
	(b)	(i)	20 cos 40 ✓ = 15.3 (kN) ✓	2	**ALLOW** evidence that cos 40 and 20 is used with any mathematical operator in any equation for first marking point. eg cos 40 ÷20. **ALLOW** answers given to 2 sf [15]
		(ii)	15.3 – 7 = 8.3 ✓ = 8300 (N) ✓	2	**ALLOW** ecf of any value with 2sf from (i). If candidate has given answer to (i) as 15, the answer here is 8000. This gets both marks. Common error is to use sin 40 in part (i) and this would give resultant force = 12.86 -7 = 5.86kN = 5860 N. This gets 2 marks with ECF.

Question			Answer	Marks	Guidance
		(iii)	ANY 2 OF: ✓✓ Pressure decreases with height / lower pressure (higher up). Because less weight of air/atmosphere above. Density of air/atmosphere reduces with altitude OR particles are more spread out. Less (frequent) collisions with (air) particles/molecules.	2	**IGNORE** any reference to changes in *g*. **NOT** just less air. **NOT** thinner air. **ALLOW** fewer particles or less mass per (unit) volume. […. Per unit area is good enough – comparable with more spread out]. **NOT** just air on its own – collisions must be with particles or molecules.
2			**TOTAL**	**11**	

Question			Answer	Marks	Guidance
3	(a)	(i)	The henry is an SI derived unit. ✓	1	Middle row ticked. Accept any clear indication of correct answer.
	(a)	(ii)	volt ✓ ampere ✓ second ✓	3	**ALLOW** amp **ALLOW** symbols, V, A, s (correct case)
	(b)	(i)	Evidence of correct current read-off at 10ms = +1mA ✓ Substitution of L and N into correct equation (either including *I* or a value for *I*; $L = \frac{N\Phi}{I}$; $0.6 = \frac{200\,\Phi}{1\times10^{-3}}$ ✓ Rearrangement $\Phi = \frac{0.6 \times 1\times10^{-3}}{200}$ = (3×10^{-6} Wb) ✓ Final value to correct POT = 3.0 (μWb) ✓	4	Read-off **IGNORE** POT for substitution and rearrangement marks. Substitution and rearrangement can be done in either order. Only lose 1 mark max for one or more POT errors. **ALLOW** 3 μWb. IF current read-off is incorrect or missing, then max 2 marks for substitution and rearrangement if working is shown.
	(b)	(ii)	0 ✓	1	
	(b)	(iii)	6.0 ✓ change is double the answer in part (i)	1	**ALLOW** 6 μWb. **IGNORE** sign **ALLOW** ecf from b(i).
	(c)		Substitution into equation $E = ½\ LI^2 = 0.5 \times 2.5 \times (40\times10^{-3})^2$ Evaluation = 0.0020 OR 2.0×10^{-3} (J)	2	**IGNORE** POT for substitution mark. **ALLOW** answer given to 1 sf. **SPECIAL CASE** If candidate has correctly converted 40mA and then only omitted to square the current, then one mark can be awarded.
3			**TOTAL**	**12**	

Question			Answer	Marks	Guidance
4	(a)		(Large amount of) work done / energy stored ✓ before the metal/material fails ✓ (dependent mark)	2	'before the metal/material fails' does not gain mark unless the first mark is awarded. **NOT** 'opposite of brittle' unless brittle is defined correctly. **ALLOW** one mark for either of the following for the second marking point only (not dependent): considerable plastic deformation cracks are stopped propagating by blunting the end of the cracks (or wtte). *Definition of toughness: A measure of the amount of work done / energy stored in a material before it breaks.*
	(b)		Increases / gets bigger / they move apart ✓	1	**ALLOW** 'it' stretches as long as 'it' is not atoms.
	(c)	(i)	An extra (partial) plane/row of atoms ✓ Disrupting / causing a defect / irregularity / mistake in a crystal / lattice or (atomic) structure ✓	2	**ALLOW** a gap in a row/plane/layer of atoms for first marking point. 'gap in structure', 'gap between particles' are not good enough. 'gap in bonds'is just good enough with BOD Award both marks for a diagram similar to this  *Definition of dislocation: an extra partial plane of atoms in a crystal structure.*

Question			Answer	Marks	Guidance
	(c)	(ii)	ANY 2 of: ✓✓ (rows of atoms/dislocations) slide past each other / slip occurs (planes of) atoms can (more easily) move into the spaces/defects (in the structure) fewer bonds broken / reformed	2	Award up to 2 marks for diagram(s) indicating the planes of atoms/dislocation moving along a crystal. eg diagram would gain one mark. In order to get the second mark, either a second diagram or some explanation/clear labelling is necessary.  **IGNORE** weaker bonds.
4	**(d)**		Measuring the ultimate tensile strength. ✓ Tests only a sample of the cables. ✓	2	Bottom two boxes ticked. **ALLOW** any clear indication of correct answers. If more than 2 boxes are ticked then no marks can be awarded.
4			**TOTAL**	**9**	

Question			Answer	Marks	Guidance
5	(a)		72000 (N) ✓	1	**ALLOW** 72 if k is added to N on answer line.
	(b)	(i)	Substitution into $U = Vpg$ = 3.2 × 1200 × 9.8 ✓ = 37632 (N) ✓	2	**ALLOW** final answer if it correctly rounds to 2sf as 38000.
	(b)	(ii)	72000 – 37632 = 34368 (N) ✓	1	**ALLOW** ecf of value to 2sf from part (a) and (b)((i). If candidate has used rounded value of Upthrust of 38000; 72000 – 38000 = 34000.
	(c)	(i)	turbulent OR turbulence ✓	1	
	(c)	(ii)	Laminar (boundary or sub-layer) Boundary layer is where the water is in contact with the support (wtte)	2	**ALLOW** layer of water around the cylinder. Candidate may have indicated location on the diagram.
	(d)		Viscosity is a fluid's ability to resist shear forces ✓ Viscosity is zero for an ideal fluid ✓	2	Bottom two boxes ticked. **ALLOW** any clear indication of correct answers. If more than 2 boxes are ticked then no marks can be awarded.
5			**TOTAL**	**9**	

Question			Answer	Marks	Guidance
6	(a)		Internal ✓ Kinetic ✓	2	
	(b)	(i)	The system does not apply a force to its surroundings ✓	1	Middle box ticked. **ALLOW** any clear indication of correct answer.
	(b)	(ii)	$Q = (W_2 - W_1) + W$ AND $W = 0$ (work done by the system = 0)✓ *Q (energy supplied)* is also = 0, therefore $W_1 = W_2$ *(energy entering = energy leaving)* ✓	2	**NOT** just stating that $W_1 = W_2$
	(c)	(i)	Substitution into $E = mc\Delta T = 0.20 \times 4200 \times (50\text{-}10)$ ✓ = 33600 J (34000J 2sf) ✓	2	**ALLOW** first marking point for candidates who substitute correct values for m and c, but then convert ΔT to 313 Kelvin. Answer will be 263000.
	(c)	(ii)	Double mass => half temp change OR mass is inversely proportional to temp change OR calculation $\Delta T = E / mc = 33600 / (0.4 \times 4200)$ ✓ ΔT = 20° ✓ T_{final} = 60°C ✓	3	ΔT = 20° gain first two marking points.
	(d)		Substitution into $E = mL = 0.017 \times 2.3 \times 10^6$ = 39100 (J)	2	**IGNORE** POT for substitution mark. **ALLOW** final answer to 2sf 39000 J
6			**TOTAL**	12	

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