Cambridge Technicals
Engineering

Unit 2: Science for engineering

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

Mark Scheme for January 2023

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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 10 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% (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 the RM Assessor messaging system, 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.

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,
   - text could be underlined or symbols adjacent to the question.

   Award Zero '0' if:
   - anything is written <u>in the answer space</u> 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. *A*ssistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. **Annotations (updated for RM assessor marking)**

Annotation	Meaning
✓	correct response worthy of a mark. **number of ticks = no of marks awarded**
✗	incorrect
^	missing something
ECF	error carried forward
BOD	benefit of doubt
NBOD	benefit of doubt not given
POT	power of ten error
CON	contradiction
RE	rounding error
SF	significant figure error
BP	blank page (to be used on the additional pages if nothing is written there.
SEEN	to indicate that an examiner has seen a response or page

11. **Subject specific marking instructions**

In all numerical calculation questions a correct response on the answer line will gain all marks unless specified otherwise.
You do not need to see all the workings if the answer on the answer line is correct.
If there is nothing or an incorrect value on the answer line then the workings must be marked. If the answer line is blank full marks can still be awarded as long as the final correct answer is clear.
Numerical answers are expected to be given to 2 SF unless otherwise specified. Candidates' answers given to more than 2SF but round correctly to the accepted answer will gain full credit.

<table>
<tr><th colspan="3">Question</th><th>Solution</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>centi (c) 10^{-9}
mega (M) 10^{-3}
milli (m) 10^{-2}
nano (n) 10^{6}
✓✓</td><td>2</td><td>To gain both marks all three lines must be correct.
One correct, award one mark</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>(1.565 – 1.500 =)
0.065 (cm) ✓</td><td>1</td><td>Ignore sign of answer, if given</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>0.065 ÷ 1.500 ✓
= 0.043 OR 4.3 % ✓</td><td>2</td><td>E CF from bi
1 mark for 0.042 (0.04153…) (i.e. division by measurement instead of true value).
If answer is given in %, the % symbol must be shown.
ACCEPT 0.043 cm, but not other units given.</td></tr>
<tr><td></td><td>(b)</td><td>(iii)</td><td>Standard deviation = 1.8×10^{-3}
<table><tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>Mean</th></tr><tr><td>Diameter / cm</td><td>1.565</td><td>1.563</td><td>1.566</td><td>1.565</td><td>1.561</td><td>1.564</td></tr><tr><td>$x - \bar{x}$</td><td>0.001</td><td>−0.001</td><td>0.002</td><td>0.001</td><td>−0.003</td><td></td></tr><tr><td>$(x - \bar{x})^2$</td><td>1×10^{-6}</td><td>1×10^{-6}</td><td>4×10^{-6}</td><td>1×10^{-6}</td><td>9×10^{-6}</td><td>3.2×10^{-6}</td></tr></table>Standard deviation = $\sqrt{\frac{1}{N}\sum^{N}(x - \bar{x})^2} = \sqrt{3.2 \times 10^{-6}} = 1.8\times10^{-3}$</td><td>4</td><td>Correct answer gets 4 marks
IGNORE any units.
No need for table completion

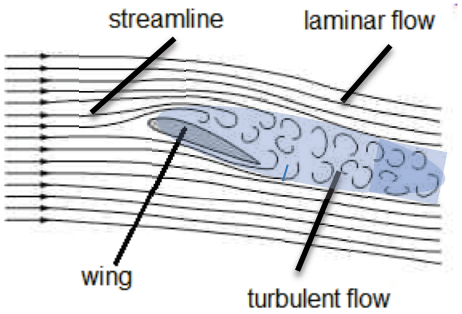
If incorrect and table has been completed award:
First mark for at least 3 correct deviations $(x - \bar{x})$.
Second mark for at least 3 squared deviations $(x - \bar{x})^2$.
Third mark for mean squared deviation (3.2×10^{-6}).

If $(n - 1)$ used as divisor then final answer will be 2.0×10^{-3}. This should gain full marks.</td></tr>
<tr><td>1</td><td></td><td></td><td>TOTAL</td><td>9</td><td></td></tr>
</table>

Question			Solution	Marks	Guidance
2	(a)		Single straight line for the first 3s from the origin with positive gradient ✓ Line passes through (3, 15) ✓	2	Accept the line going beyond 3 s. (3,15) judged by eye to be in the middle of square. Line does not need to be drawn with a ruler, but a correct line should also pass through (2,10) and look straight by eye.
	(b)		v^2 $(= u^2 + 2as)$ = 0 + 2 × 4.0 × 18 ✓ = 144 ✓ v = 12 (m s^{-1}) ✓	3	Substitution of values into SUVAT equation. ALLOW $s = ut + \frac{1}{2}at^2$ to give t = 3 s for first marking point. Then substituting into $v = u + at$ for second marking point and final answer correct for third marking point.
	(c)	(i)	2 (s) ✓	1	1 SF is acceptable here.
	(c)	(ii)	$W = (F\,d\,=)$ 4000 × 70 ✓ = 280 000 (J) ✓	2	IGNORE POT in substitution mark but final mark will not be awarded. Allow 280 kJ in answer space for 2 280 without k scores 1
	(c)	(iii)	$P = (E \div t =)$ 280000 ÷ 2 OR $P = (F\,v =)$ 4000 × 35 ✓ = 140000 (W) ✓	2	Allow ecf of values from (i) and (ii). Only penalise omitting 10^3once in this question. Answer for part (iii) should be consistent POT with answer in part (ii).
2			**TOTAL**	**10**	

Question			Solution	Marks	Guidance
3	(a)	(i)	Second box from left is ticked ✓	1	
	(a)	(ii)	$I = (V \div R =)\ 12 \div 48$ ✓ $= 0.25$ (A) ✓	2	First mark for substitution.
	(a)	(iii)	$(\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} =) \frac{1}{24} + \frac{1}{48}$ ✓ $(\frac{1}{R_T} =) \frac{3}{48}$ or 0.0625 ✓ $R_T = 16$ (Ω) ✓	3	No marks for stating equation. First mark is a substitution mark. Award this mark for evidence of RH side of equation substituted correctly. Second mark for correct addition of fractions. **DO NOT ALLOW** final answer in fraction form.
	(b)		Second from left is ticked. ✓	1	
	(c)	(i)	Line with negative gradient starting from positive (≠ 0 or ∞) value at t = 0. ✓ Negative gradient of line gets less steep as t increases. ✓	2	NOT gradient = 0 at the beginning. DO NOT ALLOW lines with positive gradient for either mark.
	(c)	(ii)	$V = V_0\, e^{-\frac{t}{CR}}$ ✓ $V = 24\, e^{-\frac{360}{85\times20}}$ ✓ $V = 19$ (V) ✓	3	Evidence of formula. Substitution. Award this mark if t = 6 instead of 360. If the candidate has written down the correct substitution they must have used the correct equation so will get at least 2 marks.
3			**TOTAL**	**12**	

Question			Solution	Marks	Guidance
4	(a)		First space: resultant ✓ Second and third spaces: attractive ✓, repulsive ✓	3	Correct answer only. Answers in either order.
	(b)		Extension is proportional to load OR force = a constant multiplied by extension (or wtte), ✓ up to (the elastic) limit OR for small extensions. ✓ *(this mark cannot usually be awarded if the first mark has not been gained)*	2	ALLOW stress proportional to strain. If symbol equations or relationships are used, then the symbols must be defined/described. ALLOW within an elastic region.
	(c)		Extension, $x = 0.8 - 0.2 = 0.6$ (nm) ✓ (E = area under the graph or ½ $F x$ =) ½ × 6.5nN × x ✓ = 1.95 ✓ ALLOW 2sf answer eg 2.0 NOT just 2 × 10^{-18} J ✓	4	Ignore POT for these first 3 marks. Second marking point is for substitution of **value of force** into correct relationship. **ALLOW** $6.4 \leq F \leq 6.6$ for this mark. **IGNORE** value of x for this mark. **DO NOT ALLOW** incorrect value of F here. **ALLOW** final answer to be between 1.92 and 1.98 as range. **ALLOW** ecf of x=0.8 to give 2.6. Final mark for correct POT. This is an independent mark.
4			**TOTAL**	9	

<table>
<tr><th colspan="3">Question</th><th>Solution</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td></td><td>
<table>
<tr><th></th><th>Volume</th><th>Density</th></tr>
<tr><td>Gas</td><td>decreases ✓</td><td>increases ✓</td></tr>
<tr><td>Liquid</td><td>stays the same ✓</td><td>stays the same ✓</td></tr>
</table>
</td><td>4</td><td>One mark per correct box.</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Lines added to diagram:
Streamline –label MUST END on a LINE (as opposed to an eddy) ✓
Laminar flow –where flow lines are roughly parallel ✓
Turbulent flow – where the lines are forming eddies (see shaded area)✓
 
</td><td>3</td><td>Laminar flow should point to area left of wing or in the region of the top 4 and bottom 6 streamlines to the right of leading edge.
Turbulent label will be where it is not laminar – see above. and shaded area of diagram shows turbulent area roughly.</td></tr>
<tr><td></td><td>(c)</td><td></td><td>(Least viscous) water, detergent, treacle (most viscous) ✓</td><td>1</td><td>All in the correct order for 1 mark.</td></tr>
<tr><td></td><td>(d)</td><td></td><td>(Kinematic viscosity) is ratio of dynamic viscosity to density
OR = dynamic viscosity ÷ density = $1.05 \times 10^{-3} \div 1030$ ✓
= 1.0(2) × 10^{−6} ($m^2\ s^{-1}$) ✓</td><td>2</td><td>Stating relationship or equation, this could be shown by correct substitution if equation not written.
Minimum of 2SF needed.
If answer is given to only 2sf, the method of calculation should be correct.</td></tr>
<tr><td>5</td><td></td><td></td><td>TOTAL</td><td>10</td><td></td></tr>
</table>

Question			Solution	Marks	Guidance
6	(a)		Pressure × volume = constant OR pressure and volume are inversely proportional OR pressure ∝ 1/Volume OR Volume ∝ 1/pressure ✓ for an ideal gas / at constant temperature ✓	2	If symbol equations or relationships are used, then the symbols must be defined/described.
	(b)	(i)	Use of PV = constant. ✓ Substituting values correctly into relationship, eg $V = (100 \times 50) \div 150$ ✓ = **33** (cm^3) ✓	3	First mark can be awarded if PV=constant or $P_1V_1 = P_2V_2$ is seen.
	(b)	(ii)	Any 2 of: Pressure in tyre increases,✓ Pressure (of air in pump) needs to be greater than the pressure of air in the tyre (in order to open valve), ✓ (Cross-sectional) area of pump is constant OR force is proportional to pressure ✓ Increased applied force needed. ✓	2	IGNORE references to volume
	(b)	(iii)	$(P_1V_1 \div T_1 = P_2V_2 \div T_2)$ substituting values or evaluation for one side of this equation ✓ ie: $\frac{100\times50}{293}$ OR $\frac{PV}{T} = 17.06$ OR $\frac{250\times25}{T_2}$ OR $\frac{PV}{T} = \frac{6250}{T_2}$ Rearrangement to find T_2 ✓ eg $T_2 = 250 \times 25\left(\frac{293}{100\times50}\right)$ OR $T_2 = \frac{6250}{17.06}$ etc = **370** (K) ✓	3	Either the substitution or the equation need to be seen. **Actual value =366 K** MAX one mark for use of T in Celsius.
6			**TOTAL**	**10**	

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