Cambridge Technicals
Engineering

Unit 2: Science for engineering

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

Mark Scheme for June 2023

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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% (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.

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

   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
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
SEEN	seen
BP	blank page

Mark Scheme abbreviations

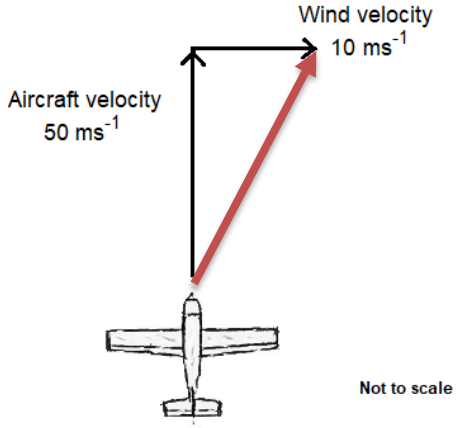
Wtte: words to that effect

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.

Question			Answer	Marks	Guidance
1	(a)	(i)	mole ✓ candela ✓	2	**ALLOW** mol, Mol **ALLOW** cd, Cd **ALLOW** plural or plurals. **ALLOW** candella and other phonetically correct misspelled attempts.
		(ii)	One correct line drawn ✓ 2nd and 3rd correct lines drawn ✓ micro (μ) • • 10^{-9} milli (m) • • 10^{-6} nano (n) • • 10^{-3}	2	
	(b)	(i)	0.01 ÷ 2.64 (= 0.0037878…) ✓ (× 100) = **0.4** (%) ✓	2	**ALLOW** correct value given to more than 1 sf
		(ii)	ANY **TWO** of: ✓✓ Can't press the button immediately (the robot begins or gets to the end); Due to (human) reaction time; (Reaction time is) significantly larger (than 0.01s) / (at least)10× larger (than 0.01s) / about 0.1 to 0.6 s ±0.01s the meter sensitivity / smallest scale division;	2	**NOT** human error **NOT** just 'larger'
		(iii)	Sum = 13.05 13.05 ÷ 5 = **2.61** (s) ✓	1	Answer must be given to 3 sf.

Question			Answer	Marks	Guidance
		(iv)	No value (of time) is within 0.01s ✓ of the mean value / any other value. ✓ **OR** large range of values or a calculation of the range greater than (0.02 or 0.01) **OR** large spread of values or a calculation of the spread greater than (0.01)	2	If any one value of time is shown to be not within 0.01s of another value or the mean that gets one mark. For the second mark they need to state why they are using 2.64 and the mean. **ALLOW** a calculation of either range or spread for one mark. Eg. Spread: half range (= 0.3) OR highest - mean (= 0.3) OR mean - lowest (= 0.3). Range: highest value – lowest value (2.86 – 2.28 = 0.6) Allow ecf from mean calculated in part (iii) **IGNORE** explanation of why the data is scattered.
1			**TOTAL**	**11**	

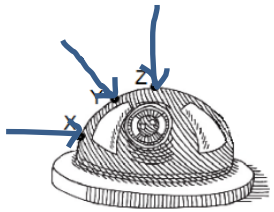
Question			Answer	Marks	Guidance
2	(a)	(i)	Straight line drawn with arrow in correct direction approximately the length shown at approximately the angle shown below. The ends of the resultant vector should meet the ends of the printed arrows within ±3mm. ✓  	1	If the line is drawn elsewhere on the page the angle and need to be checked. **ALLOW** candidate to draw a scale diagram vector triangle. **ALLOW** new sketch diagram drawn on top of the existing image, including either a new length for wind or aircraft velocity. Arrowhead can be anywhere on the line but must point in correct direction. Line needs to look like a straight line, but not necessarily with a ruler.
	(a)	(ii)	Evidence of use of Pythagoras equation eg 50^2+10^2 (= 2600) ✓ Resultant velocity = $\sqrt{(50^2 + 10^2)} = \mathbf{51}$ (ms^{-1}) ✓	2	A bald answer of 41 gains both marks. **ALLOW** answers given to more than 2sf eg 50.99. **IGNORE** scale drawing.
	(b)	(i)	**C** ticked ✓	1	

Question			Answer	Marks	Guidance
	(b)	**(ii)**	Use of $s = v\,t$; i.e. v=70 and a value of time substituted OR (distance travelled =) correct shaded area shown on the graph ✓ (Conversion of correct time period (35 minutes) into seconds) t = 2100 ± 120 s ✓ (s = 70 × 2100 =) **147000** (m) [range 139000 to 155000]✓	3	**ACCEPT** only the following values of t substituted into $s = v\,t$. 35±2, 55±1, 20±1 minutes,or 2100±120, 3300±60 or 1200±60. [half a small square tolerance on reading the graph]. If no conversion to seconds, then$s$ = 2450; 2 marks awarded. If the 55 or 20 minutes are used then only the first marking is available. **ALLOW** final value to 2sf.
	(c)		Either of the following: ✓ Rate of doing work **OR** Work (done) divided by time **OR** Work (done) per (unit) time. Rate of energy transfer **OR** Energy (transferred) divided by time **OR** Energy (transfer) per (unit) time.	1	**ALLOW** work or energy over time. If symbols are used eg E/t then the symbols need to be defined. **DO NOT ALLOW** units to be used eg joules per second or work done per second. **IGNORE** force × velocity.
2			**TOTAL**	**8**	

Question			Answer	Marks	Guidance
3	(a)		Any **TWO** from: ✓✓ strength / strong endurance or resistance to fatigue stiff(ness) tough(ness) ductility / ductile	2	**ALLOW** UTS or ultimate tensile stress. **ALLOW** high modulus for stiff **DO NOT ALLOW** negative statements eg not weak.
	(b)		Substitution into Energy = mgh = 75 × 9.8 × 30 ✓ = **22000** (J) ✓	2	**ALLOW** use of g = 10ms^{-2} to give answer of 22500 or 23000 J for both marks. Watch out for candidates missing out g in the equation and getting a value 2250 J. [0]
	(c)	(i)	joule per coulomb ✓	1	**ALLOW** joule divided by coulomb, joule over coulomb, J C^{-1} or J/C **NOT** energy per unit charge.
	(c)	(ii)	Correct substitution into $V = \frac{E}{Q}$; 230= $\frac{146}{Q}$ $(Q = 635)$✓ Then use $Q = It$ to find current: $V = \frac{E}{It}$ or $230 = \frac{146}{42 \times I}$ or $635 = I \times 42$ ✓ Rearrangement and correct POT to give final value for $I = 15$ (A) ✓ **OR** Correct substitution into $P = \frac{W}{t}$; $P = \frac{146}{42}$ $(P = 3476)$ ✓ Then use $P = VI$ to find current: $VI = \frac{W}{t}$; $230 \times I = \frac{146}{42}$ or $230 \times I = 3476$ ✓ Rearrangement and correct POT to give final value for $I = 15$ (A) ✓ **OR** Recall $E = VIt$, which is not in the formula booklet ✓ Correct substitution; $146 = 230 \times I \times 42$ ✓ Rearrangement and correct POT to give final value for $I = 15$ (A) ✓	3	Correct answer of 15A will gain all three marks. DO not allow substitution of energy into Q=It (which give I = 3476 in the working). If conversion of 146 kJ omitted or incorrect (leading to incorrect POT in final answer) first two marks can still be awarded. Max 2 marks. **IGNORE** POT for the first two marks of all the methods.

Question			Answer	Marks	Guidance
	(d)		**Energy** ticked ✓	1	
	(e)	(i)	Ratio of the work output to work input ✓	1	**ALLOW** definition in terms no named quantity or power or energy instead of work. **ALLOW** percentage of useful energy/work/power **ALLOW** work output ÷ work input Watch out for inverted fraction.
	(e)	(ii)	Substitution into Efficiency $= \frac{\text{work output}}{\text{work input}}$ (any subject and ignore POT), eg 40 (%) $= \frac{32}{input}$ ✓ Rearrangement (and correct POT) to give Energy input = **80** (kJ) ✓	2	
	(f)		Evidence of equations: $W = \frac{1}{2}QV$ AND $Q = CV$ OR $W = ½\ CV^2$ ✓ Rearrangement and substitution to give $V^2 = 2W/C = (2 \times 32 \times 10^3) \div 45$ (= 1422) ✓ $V =$ **38** (V) ✓	3	If these equations are shown, and there are no contradictory statements or equations shown the first mark can be awarded. If no or incorrect conversion of 32 kJ to 32×10^3 J then max 2 marks can be awarded.
3			**TOTAL**	**15**	

Question			Answer	Marks	Guidance
4	(a)		Large permanent or plastic deformation ✓ (Deforms) without failure ✓	2	**ALLOW** Can be drawn into wires for first marking point. Second mark is dependent on the first mark.
	(b)		Use of $I = nAve$. EITHER a correct rearrangement to find $v = I \div nAe$ OR correct substitution of I, n and A; $700 = 6.0\times10^{28} \times 1.3\times10^{-3} \times v \times e$ ✓ v= **5.6 x 10^{-5}** (ms^{-1}) for second marking point. ✓	2	**IGNORE** the value or symbol inserted for e, as long as there is either a number or a symbol in the equation. Do not award any marks for candidates who multiply the given numbers together to get 5.46×10^{28}.
	(c)	(i)	Calculation of weight of cable = 4.5 × 9.8 × 1200 (= 53000 (N)) ✓ Substitution into $\sigma = F \div A = 53000 \div 1.3\times10^{-3}$ ✓ = **4.1×10^{7}** (Pa) OR 41 MPa ✓	3	No penalty for using g = 10; $\sigma = 41.5\times10^{6}$ Pa, so allow 42×10^{6} for full marks. If mass of cable used instead of weight, then $\sigma = 4.2\times10^{6}$ Pa one mark available. If 4.5 kg m^{-1} as F then no marks available.
	(c)	(ii)	Any **TWO** from: ✓✓ (Otherwise) the cable fails or breaks **OR** UTS is the maximum (stress) the material can withstand before failure. Safety factor needs to be included. Additional loading due to other factors eg wind/environmental. The cable might plastically deform / elastic limit is below UTS. The cable might suffer creep or fatigue at stresses below UTS.	2	
4			**TOTAL**	9	

Question			Answer	Marks	Guidance
5	(a)	(i)	 3 arrows directed towards dome at X, Y and Z. ✓ All arrows (at least 3) at right angles (by eye) to surface of dome. ✓	2	If any arrows are drawn other than at X, Y, Z all the arrows need to be correct to gain either mark. Arrow at X can range from horizontal to angled towards the centre of the elliptical base (3D diagram).
		(ii)	Substitution into $P = hpg$ = 64 x 1200 x 9.8 ✓ P = 752640 ✓ Answer rounded to 2 or 3 sf. P = **750000** or **753000** unit **Pa**	4	**ALLOW** use of g = 10 to get the value 76800, which then rounds to 77000 to 2sf. Unit has to be consistent with value on answer line. **ALLOW** Nm^{-2} or pascal or a correct conversion to kPa eg 750 kPa. Do not allow pA – this looks like pico-amps.
		(iii)	Absolute (pressure) = atmospheric (pressure) + gauge (pressure). ✓✓ OR any **TWO** from: (atmospheric) pressure acts on the surface of the water ✓ atmospheric pressure needs to be taken into consideration (to get absolute pressure) OR gauge pressure does not include atmospheric pressure ✓ gauge pressure is measured pressure above (atmospheric pressure) ✓	2	Words to the effect of the equation gets both marks (any subject).
	(b)		**stiff**(ness) ✓	1	**ALLOW** high modulus (of elasticity)
5			**TOTAL**	**9**	

Question			Answer	Marks	Guidance
6	(a)		Liquid ✓	1	**ALLOW** a named liquid e.g. water **ALLOW** plasma
	(b)	(i)	(27 + 273 =) **300** (K) ✓	1	**ALLOW** 300.15
	(b)	(ii)	(-3°C is 270K) (Use of V/T = const) eg $\frac{0.02}{300} = \frac{V}{270}$ or $\frac{270}{300} = \frac{V}{0{,}02}$ ✓ volume = **0.018** (m^3) ✓	2	**ALLOW** ecf from part (i) and a consistent incorrect conversion of -3° for both marks. **DO NOT ALLOW** use of temperatures in °C.
	(c)		Specific ✓ Latent heat ✓ of condensation (or vaporisation) ✓	3	 **NOT** condenses. **ALLOW** condensing or vaporising
	(d)		Absolute zero ✓	1	
6			**TOTAL**	**8**	

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on

01223 553998

Alternatively, you can email us on

support@ocr.org.uk

For more information visit

ocr.org.uk/qualifications/resource-finder

ocr.org.uk

Twitter/ocrexams

/ocrexams

/company/ocr

/ocrexams

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT

OCR is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

OCR operates academic and vocational qualifications regulated by Ofqual, Qualifications Wales and CCEA as listed in their qualifications registers including A Levels, GCSEs, Cambridge Technicals and Cambridge Nationals.

OCR provides resources to help you deliver our qualifications. These resources do not represent any particular teaching method we expect you to use. We update our resources regularly and aim to make sure content is accurate but please check the OCR website so that you have the most up-to-date version. OCR cannot be held responsible for any errors or omissions in these resources.

Though we make every effort to check our resources, there may be contradictions between published support and the specification, so it is important that you always use information in the latest specification. We indicate any specification changes within the document itself, change the version number and provide a summary of the changes. If you do notice a discrepancy between the specification and a resource, please contact us.

Whether you already offer OCR qualifications, are new to OCR or are thinking about switching, you can request more information using our Expression of Interest form.

Please get in touch if you want to discuss the accessibility of resources we offer to support you in delivering our qualifications.