# Cambridge Technicals
# Engineering

## Unit 1: Mathematics for engineering

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

# Mark Scheme for January 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.

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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 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. There is a NR (No Response) option. Award NR (No Response)
   - 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 question

   Note: Award 0 marks - for an attempt that earns no credit (including copying out the question)

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 |
|  | Incorrect response |
|  | Missing something |
|  | Follow through |
|  | Benefit of doubt |
|  | Ignore subsequent working |
|  | Method mark awarded 0 |
|  | Method mark awarded 1 |
|  | Accuracy mark awarded 0 |
|  | Accuracy mark awarded 1 |
|  | Independent mark awarded 0 |
|  | Independent mark awarded 1 |
|  | Special Case |

**Mark scheme abbreviations**

| Other abbreviations in mark scheme | Meaning |
|---|---|
| oe | Or equivalent |
| Soi | Seen or implied |
| www | Without wrong working |
| ecf | Error carried forward |

11. **Subject-specific marking instructions**

Annotations should be used whenever appropriate during your marking.

**The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks.** It is vital that you annotate standardisation scripts fully to show how the marks have been awarded. These annotations must be in the body of the work and **not** anywhere near the right-hand margin of each page.
Mark in using a red pen.
Put the mark for each subquestion near to and to the right of the mark for the question. Total all marks for the question and put this total in a ring at the bottom right of each question.
Transfer these marks to the box on the front page.
Total the marks for the paper. I suggest that all unringed marks are then totalled to make sure that the final mark is correct.

An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks, but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

The following types of marks are available.

**M**
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases, the nature of the errors allowed for the award of an M mark may be specified.

**DM**
A method mark which is dependent on a previous method mark.

**A**
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

**B**
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

Rules for replaced work

If a candidate attempts a question more than once and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate. This is achieved by withholding one A mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | | $2(3x-2)$ | B1 | |
| | | | | [1] | |
| | (b) | | $(2x+y)^3=(2x)^3+3(2x)^2y+3(2x)y^2+y^3$<br>$=8x^3+12x^2y+6xy^2+y^3$ | M1<br>A1<br>A1 | Use of binomial (i.e. 4 terms with correct powers)<br>Sight of at least one correct coefficient (not including 1)<br>All correct |
| | | | Alternative:<br>$(2x+y)(4x^2+4xy+y^2)$<br>$=8x^3+8x^2y+2xy^2+4x^2y+4xy^2+y^3$<br>$=8x^3+12x^2y+6xy^2+y^3$ | M1<br>A1<br>A1 | Multiply linear with expanded quadratic (powers correct but coefficients do not need to be).<br>Expanded with at least one coefficient correct (not including 1)<br>All correct |
| | | | | [3] | |
| | (c) | | $x-2\overline{)x^3-5x^2+6x-3}$<br>$x^2$<br>$x^3-2x^2$<br>$\Rightarrow$ Quotient $x^2-3x$<br>Remainder $-3$ | M1<br>A1<br>A1 | Sight of $x^2$ in quotient and multiplication of $x-2$ by $x^2$<br>Quotient. isw<br>Remainder. isw<br>SC If M0, Remainder -3 www B1 |
| | | | Alternative:<br>Division or "back multiplication" | M1<br>A1<br>A1 | $\Rightarrow$ Sight of $x^2+ax$ and $(x-2)$ for any $a\neq 0$<br>Quotient<br>Remainder |
| | | | | [3] | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | (i) | | B is at $(7,8)$<br>M is at $(3.5,4)$ | **B1**<br>**B1** | Soi by correct answer<br><br>i.e. B2 for correct answer. Accept without brackets |
| | | | | **[2]** | |
| | (ii) | | Gradient $= -\frac{8}{7}$<br>Intercept on $y$-axis is 8.<br>$\Rightarrow y = -\frac{8}{7}x + 8$ **oe** | **B1**<br>**B1**<br>**B1** | Soi. Allow decimal value here (-1.14…)<br><br>soi<br><br>i.e. $8x + 7y = 56$, but must be exact. |
| | | | | **[3]** | |
| | (iii) | | $-\frac{8}{7} \times \frac{7}{2} + 8 = -4 + 8 = 4$ | **B1** | Answer given so must be convincing<br>i.e. substitute 3.5 and get 4<br>or substitute 4 and get 3.5<br>or substitute (3.5, 4) and show that lhs = rhs<br>Or "diagonals of a rectangle intersect at their midpoints" **oe** |
| | | | | **[1]** | |

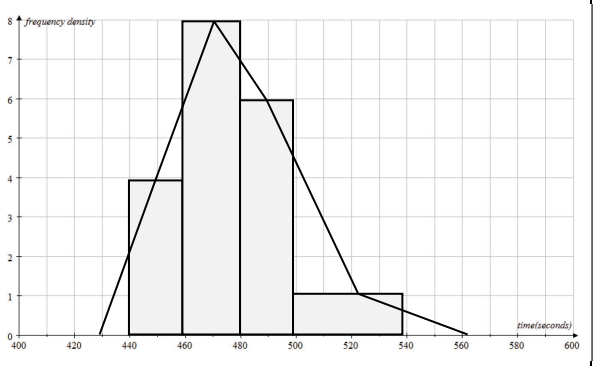
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | | $T_1 = \frac{5}{9}T_2$<br>$\Rightarrow 5\times\frac{5}{9}T_2 + 9T_2 = 1000$<br>$\Rightarrow \left(\frac{25}{9}+9\right)T_2 = 1000 \Rightarrow \frac{106}{9}T_2 = 1000$<br>$\Rightarrow T_2 = \frac{9000}{106} = \frac{4500}{53}(\text{N}) \Rightarrow T_1 = \frac{2500}{53}$ (N)<br>or $T_1 = 47.2(\text{N}),\quad T_2 = 84.9(\text{N})$ | M1*<br><br>A1<br><br>M1dep<br><br>A1 | By elimination or substitution to obtain an equation in one of the variables.<br><br>Correct equation i.e. $\frac{45}{9}T_2 + 9T_2 = 1000$ or $5T_1 + \frac{81}{5}T_1 = 1000$ (implied by a correct value)<br>Substitution of one value to get 2nd value<br><br>Both values , fractional or decimal (anything that rounds to correct 2sf)<br>SC Final answers with no working B4<br>Accept with no units but if there are units they must be correct (i.e. N) |
| | | | | [4] | |
| | (b) | | $(x+a)(x+b) \quad (=0)$<br>$\Rightarrow (x+7)(x-4) \quad (=0)$<br>$\Rightarrow (x=)-7,\ 4$ | M1<br>A1<br><br>A1 | Factorisation with $ab = \pm 28$ or $a+b = \pm 3$ or use of correct formula<br>Correct brackets or correct substitution into formula<br><br>Both answers correct www |
| | | | | [3] | |
| | (c) | (i) | $f(x) = 2(x^2-8x)+15$<br>$= 2\left((x-4)^2-16\right)+15$<br><br><br>$(f(x)=) \quad 2(x-4)^2-17$ | M1<br><br><br>A1<br><br>A1<br><br>A1 | Attempt to factorise out the 2 from 1st two terms.<br>Accept $2\left(x^2-8x+\frac{15}{2}\right)$<br>$-16$ soi by correct answer<br><br>$2(x-4)^2$<br><br>$-17$ |
| | | | | [4] | |

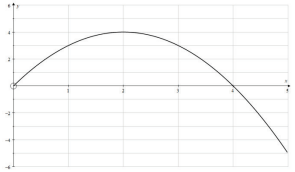
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | (c) | (ii) | $f(x)=0 \Rightarrow 2(x-4)^2-17=0$<br>$\Rightarrow x-4=(\pm)\sqrt{\frac{17}{2}}$<br>$\Rightarrow (x=)4\pm\sqrt{\frac{17}{2}}$ **oe** $(=6.92 \text{ and } 1.08)$ | **M1**<br><br>**A1** | Solve by taking square roots of *their* (c)(i)<br><br>Both roots<br>Accept decimal values which round 3 sf |
| | | | Alternative<br>$x=\frac{16\pm\sqrt{16^2-4\times2\times15}}{4}$<br>$=6.92$ and $1.08$ | **M1**<br><br>**A1** | Correct formula and correct substitutions<br><br>Both roots<br>Accept decimal values which round 3 sf<br>Accept correct values www |
| | | | | **[2]** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | | $\log x^2 + \log 2 - \log x$<br>$= \log 2x$ | **M1**<br>**A1** | Correct use of a log law<br>cao |
| | | | | **[2]** | |
| | (b) | | $RC = 5000 \times 0.0008$<br>$(= 4)$ | **M1** | Calculate RC (possibly unsimplified) |
| | | | $\Rightarrow 11 = 12\left(1 - e^{-\frac{t}{4}}\right)$ | **M1** | Substitute for $V$, RC and $V_s$ to obtain equation involving only $t$ |
| | | | $\Rightarrow e^{-\frac{t}{4}} = \frac{1}{12}$ | | |
| | | | $\Rightarrow -\frac{t}{4} = \ln\left(\frac{1}{12}\right) = -2.485$ | **M1** | Take logs |
| | | | $\Rightarrow t = 9.9.....$ | **A1** | Anything that rounds to 9.9 www |
| | | | | **[4]** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (a) | | $10 \text{ rpm} = 10 \times 2\pi = 20\pi$ rads per minute | B1 | Multiply by $2\pi$ **or** divide by 60 |
| | | | $= \frac{\pi}{3}$ $(= 1.05....)$ | B1 | If left as fraction must be reduced to lowest terms |
| | | | | [2] | |
| | (b) | (i) | $\cos \text{ABC} = \frac{8^2 + 3^2 - 7^2}{2 \times 8 \times 3} = 0.5$<br>$\Rightarrow \text{ABC} = 60^0$ | M1 | Attempt to use the cosine rule for any angle with consistent substitutions |
| | | | | A1 | Correct fraction for *their* angle (possibly unsimplified) |
| | | | | A1 | Accept radians as units |
| | | | | [3] | |
| | (b) | (ii) | $Area = \frac{1}{2} \times \text{BC} \times \text{AB} \times \sin \text{ABC}$ | M1 | Use of correct formula with *their* angle and two sides |
| | | | $= \frac{1}{2} \times 3 \times 8 \times \sin 60$ | A1 | Correct, or alternative version soi by correct answer<br>$= \frac{1}{2} 3 \times 7 \times \sin 98.2$ or $= \frac{1}{2} 8 \times 7 \times \sin 21.8$ |
| | | | $= 10.4 \text{ cm}^2$<br>Accept $\sqrt{108}$ or $6\sqrt{3}$ | A1 | Must include units<br>Accept exact surd answer<br>Any decimal answer that rounds to 3 sf correctly |
| | | | | [3] | |

| | | | | |
|---|---|---|---|---|
| Angle A | $21.8^0$ | $\text{Cos A} = \frac{13}{14}$ | $0.38^c$ | $\text{area} = \frac{1}{2} \times 8 \times 7 \sin 21.8 = 10.4$ |
| Angle B | $60^0$ | $\text{Cos B} = \frac{1}{2}$ | $1.05^c$ | $\text{area} = \frac{1}{2} \times 8 \times 3 \sin 60 = 10.4$ |
| Angle C | $98.2^0$ | $\text{Cos C} = -\frac{1}{7}$ | $1.7^c$ | $\text{area} = \frac{1}{2} \times 3 \times 7 \sin 98.2 = 10.4$ |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | (a) | (i) | <table><tr><td>11</td><td></td><td>3</td></tr><tr><td>12</td><td></td><td>3</td></tr><tr><td>13</td><td></td><td>3</td></tr><tr><td>14</td><td></td><td>2</td></tr><tr><td>15</td><td></td><td>1</td></tr><tr><td>16</td><td></td><td>2</td></tr><tr><td>17</td><td></td><td>4</td></tr><tr><td>18</td><td></td><td>2</td></tr></table> | **B2** | B1 for one error (e.g. could be 2 numbers wrong by one, one up and one down or one number 1 out)<br>Accept numbers in either column<br><br>SC Tally seen and correct but not counted B1 |
| | | | | **[2]** | |
| | **(a)** | **(ii)** | 17 | **B1** | Ft *their* tally |
| | | | | **[1]** | |
| | **(b)** | **(i)** |  | **B1**<br>**B1**<br><br>**B1*** <br><br>**B1dep** | Width of 4 blocks consistent with grid (ignore heights)<br>Heights of 1st three in proportion to each other<br>Last one $\frac{1}{4}$ of the height of 1st bar or $\frac{1}{8}$ of 2nd or $\frac{1}{6}$ of third<br>Appropriate scale on *y*-axis – accept even if not defined<br>Possibilities:<br>*f* per sec, scale:200, 400, 600 etc<br>*f* per 10 secs, scale: 20, 40, 60, etc<br>*f* per 20 secs, scale: 2, 4, 6 etc<br>*f* per class width scale 0.2, 0.4, 0.6 etc<br>This mark dependent on 3rd B mark |
| | | | | **[4]** | |
| | **(b)** | **(ii)** | Frequency polygon as above | **M1**<br>**A1** | Polygon at midintervals<br>Central three Correct<br>Accept 3 lines not 5 Accept variations of end points |
| | | | | **[2]** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | (a) | | $\int \cos 2x \, dx = \frac{1}{2}\sin 2x + c$ | B1<br>B1 | Sin $2x$ Do not award if it clearly comes from diffn. i.e. $-2\sin 2x$ is diffn<br>½<br>Must include $+c$ for full marks |
| | | | | [2] | |
| | (b) | (i) | $v = 4t - t^2$<br>$\Rightarrow a\left(=\frac{dv}{dt}\right) = 4 - 2t$<br>$= 0$ when $t = 2$ | M1<br>M1<br>A1 | Differentiate<br>Set their derivative= 0 |
| | | | | [3] | |
| | (b) | (ii) |  | B1<br>B1 | Upside down parabola with max at (2, 4)<br>Parabola through (0, 0) and (4, 0) and goes negative<br>Allow up to 0.1 either side of correct point vertically as well as horizontally |
| | | | | [2] | |
| | (b) | (iii) | $s = \int_0^4 \left(4t - t^2\right) dt = \left[2t^2 - \frac{t^3}{3}\right]_0^4$<br>$= 32 - \frac{64}{3}\ (-0)$<br>$= \frac{32}{3}(\text{m})$ | M1*<br>A1<br>M1dep<br>A1 | Integrate – ignore limits (i.e. powers increased by 1 and one coeff changed)<br>Use limits in correct order dep on 1st M1<br>Accept decimal that rounds to 10.7<br>SC Final Answer www B4<br>SC by numerical methods B2 for an answer of 10 or better |
| | | | | [4] | |

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