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CAMBRIDGE
International Education

# Cambridge International A Level

**MATHEMATICS** **9709/33**

Paper 3 Pure Mathematics 3 **May/June 2026**

MARK SCHEME

Maximum Mark: 75

**Published**

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

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**[Turn over**

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**General marking principles**

All examiners must apply these marking principles when marking candidate responses.

| | |
|---|---|
| 1 | Examiners must award marks for each response in line with:<br><br>• the specific **content** defined in the mark scheme<br>• the specific **skills** defined in the mark scheme or in the level descriptions<br>• the **standard of response** required as exemplified by the standardisation scripts. |
| 2 | Examiners must award **whole marks** (not half marks, or other fractions). |
| 3 | Examiners must award marks **positively**. This means that:<br><br>• marks are not deducted for errors or omissions<br>• marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate<br>• the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous. |
| 4 | Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly. |
| 5 | Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen. |
| 6 | Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind. |

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**Mathematics-Specific Marking Principles**

1 Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.

2 Unless specified in the question, non-integer answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.

3 Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.

4 Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).

5 Where a candidate has misread a number or sign in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 A or B mark for the misread.

6 Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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**Annotations guidance for centres**

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

**Annotations**

| Annotation | Meaning |
|---|---|
| ^ | More information required |
| A0 | Accuracy mark awarded zero |
| A1 | Accuracy mark awarded one |
| B0 | Independent accuracy mark awarded zero |
| B1 | Independent accuracy mark awarded one |
| B2 | Independent accuracy mark awarded two |
| BOD | Benefit of the doubt |
| BP | Blank Page |
|  | Incorrect |
| Dep | Used to indicate DM0 or DM1 |

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| Annotation | Meaning |
|---|---|
| DM1 | Dependent on the previous M1 mark(s) |
| FT | Follow through |
| ~~~ | Indicate working that is right or wrong |
| Highlighter | Highlight a key point in the working |
| ISW | Ignore subsequent work |
| J | Judgement |
| JU | Judgement |
| M0 | Method mark awarded zero |
| M1 | Method mark awarded one |
| M2 | Method mark awarded two |
| MR | Misread |
| O | Omission or Other solution |
| Off-page comment | Allows comments to be entered at the bottom of the RM marking window and then displayed when the associated question item is navigated to. |
| On-page comment | Allows comments to be entered in speech bubbles on the candidate response. |
| PE | Judgment made by the PE |
| Pre | Premature approximation |
| SC | Special case |
| SEEN | Indicates that work/page has been seen |

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| Annotation | Meaning |
|---|---|
| SF | Error in number of significant figures |
| ✓ | Correct |
| TE | Transcription error |
| XP | Correct answer from incorrect working |

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## Mark Scheme Notes

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

### Types of mark

**M** Method mark, awarded for a valid method applied to the problem. Method marks are not 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. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

**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).

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

**DM** or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

**FT** Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.

- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
- The total number of marks available for each question is shown at the bottom of the Marks column.
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- Square brackets [ ] around text or numbers show extra information not needed for the mark to be awarded.

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**Abbreviations**

| | |
|---|---|
| AEF/OE | Any Equivalent Form (of answer is equally acceptable) / Or Equivalent |
| AG | Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid) |
| CAO | Correct Answer Only (emphasising that no 'follow through' from a previous error is allowed) |
| CWO | Correct Working Only |
| ISW | Ignore Subsequent Working |
| SOI | Seen Or Implied |
| SC | Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance) |
| WWW | Without Wrong Working |
| AWRT | Answer Which Rounds To |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 | Use correct law of logarithm for a power or for a sum | ***M1** | Correct use of brackets SOI by later work. |
| | Remove logarithms | **DM1** | E.g. $5(3x - 2) = (x - 4)^2$.<br>Condone use of $\frac{\ln(x-4)^2}{\ln(3x-2)}$ but 'recovered' later.<br>Must see evidence of recovery |
| | Obtain a correct quadratic equation, e.g. $x^2 - 23x + 26 = 0$ | **A1** | Or three-term equivalent. |
| | Obtain final answer $x = \frac{23+5\sqrt{17}}{2}$ only | **A1** | Or exact equivalent. |
| | | **4** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2 | **EITHER:**<br>State or imply non-modular inequalities $3^{2x-1}-4<-2$ and $3^{2x-1}-4>2$,<br>or $\left(3^{2x-1}-4\right)^2>2^2$<br>or corresponding pair of linear equations or quadratic equation | **(B1** | |
| | Use correct method for solving an equation of the form $3^{2x-1}=a$ where $a>0$ | **M1** | |
| | Obtain critical values $x = 0.815$ and 1.32 or exact equivalents | **A1** | E.g. $\left(\frac{\ln 6}{\ln 3}+1\right)\div 2$ and $\left(\frac{\ln 2}{\ln 3}+1\right)\div 2$.<br>Allow greater accuracy, 1.31546…, 0.8154648… |
| | State final answer $x < 0.815$, $x > 1.32$ | **A1)** | |
| | **OR:** | | |
| | Use correct method for solving an equation of the form $3^{2x-1}=a$ where $a>0$ | **(M1** | |
| | Obtain one critical value, e.g. 0.815 or exact equivalent | **A1** | E.g. $\left(\frac{\ln 6}{\ln 3}+1\right)\div 2$.<br>Allow greater accuracy, 0.8154648…. |
| | Obtain the other critical value, e.g. 1.32 or exact equivalent | **A1** | E.g. $\left(\frac{\ln 2}{\ln 3}+1\right)\div 2$.<br>Allow greater accuracy, 1.31546…. |
| | State final answer $x < 0.815$, $x > 1.32$ | **A1)** | |

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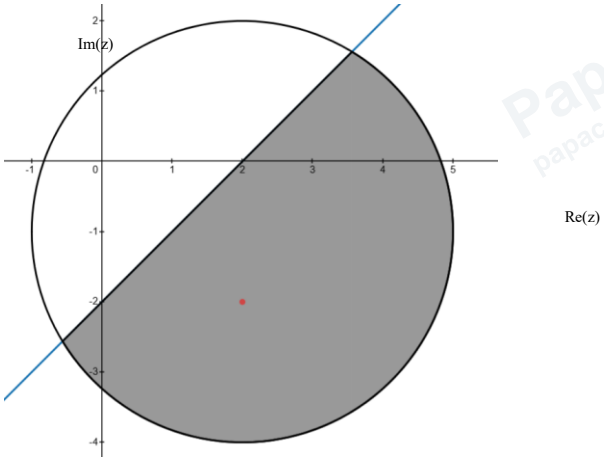


| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2 | **OR:** | | |
| | Use $y = 3^{2x}$ and hence obtain $\left(\frac{1}{3}y - 4\right)^2 > 4$ | **(B1** | OE |
| | Use correct method for solving an equation of the form $3^{2x} = a$ where $a > 0$ | **M1** | |
| | Obtain critical values $x = 0.815$ and 1.32 or exact equivalents | **A1** | E.g. $\left(\frac{\ln 6}{\ln 3} + 1\right) \div 2$ and $\left(\frac{\ln 2}{\ln 3} + 1\right) \div 2$.<br>Allow greater accuracy, 1.31546…, 0.8154648…. |
| | State final answer $x < 0.815$, $x > 1.32$ | **A1)** | Mark final answer.<br>Inclusion of 'and' is A0. |
| | Available marks | **4** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 3 | Show a circle centre (2, –1) | **B1** | Allow if stated but must have a circle shown with no contradiction. |
| | Show a circle with radius 3 | **B1FT** | FT centre not at the origin.<br>Allow if stated but must have a circle shown with no contradiction.<br>Must not pass through $(5, 0)$ and $(-1, 0)$. |
| | Show the point representing (2, –2) or the midpoint (1, –1) or the straight line passing through the origin and (2, –2) or the midpoint (1, –1)<br>Or use $y = x - 2$ (SOI by diagram) | **B1** | |
| | Show the perpendicular bisector of the line joining (2, –2) and the origin, passing through or near $(0, -2)$ and $(2, 0)$<br>Or show the line $y = x - 2$ passing through $(0, -2)$ and $(2,\ 0)$ | **B1FT** | FT is on the position of (2, –2). |
| | Shade the correct region | **B1** | Dependent on all previous marks.<br>**SC** allow B1 after B0 for inaccurate perpendicular bisector.<br> |
| | | **5** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4 | Use correct trig formulae for $\cos(2\theta - 45°)$ or for $\sin(2\theta - 45°)$ | **B1** | E.g. $\cos 2\theta \cos 45 + \sin 2\theta \sin 45$ or $\sin 2\theta \cos 45 - \cos 2\theta \sin 45$. Negative angles must be simplified correctly. |
| | Use correct trig formulae and substitute values for cos 45 and sin 45 | ***M1** | |
| | Obtain correct simplified equation, e.g. $\sqrt{2}\sin 2\theta = -1$ | **A1** | OE |
| | Solve *their* equation in sin $2\theta$ correctly to obtain a value for $\theta$ | **DM1** | |
| | Obtain answer, e.g. –22.5 | **A1** | |
| | Obtain all four answers –67.5°, –22.5°, 112.5° and 157.5° and no others in the interval | **A1** | Treat answers in degrees as a misread. Withhold one A1 only for any instances of this throughout. Correct radian answers –1 .179, –0.393, 1.96, 2.75 Ignore answers outside the given interval. |
| | | **6** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5(a) | Obtain $\frac{\mathrm{d}x}{\mathrm{d}t} = 2\sec^2 2t$ | **B1** | OE |
| | Attempt chain rule on $(\sin 2t)^{-1}$ for $\frac{\mathrm{d}y}{\mathrm{d}t}$, or attempt to use given formula | **M1** | I.e. $\frac{\mathrm{d}y}{\mathrm{d}t} = -(\sin 2t)^{-2}\frac{\mathrm{d}}{\mathrm{d}t}(\sin 2t)$.<br>Use of quotient rule must give the form $p(\sin 2t)^{-2}\cos 2t$ OE.<br>Use of formula $q\operatorname{cosec} 2t \cot 2t$. |
| | Obtain $\frac{\mathrm{d}y}{\mathrm{d}t} = -2(\sin 2t)^{-2}\cos 2t$ | **A1** | OE |
| | Use $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}t} \times \frac{\mathrm{d}t}{\mathrm{d}x}$ | **M1** | Expect $-2(\sin 2t)^{-2}\cos 2t \times \frac{\cos^2 2t}{2}$ OE if correct.<br>Use *their* $\frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}x}{\mathrm{d}t}$ correctly.<br>Condone errors when dealing with the 2's. |
| | Obtain $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{-\cos 2t}{\tan^2 2t}$ | **A1** | WWW<br>Allow from $-\frac{\cos^3 2t}{\sin^2 2t}$.<br>Must be in this form of answer given in the question. |
| | | **5** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5(b) | Obtain $x = 1$ and $y = \sqrt{2}$ when $t = \frac{1}{8}\pi$ | **B1** | |
| | Substitute $t = \frac{1}{8}\pi$ into *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ of the correct form | ***M1** | Expect $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{\sqrt{2}}{2}$ if correct, $\frac{k}{\sqrt{2}}$ if incorrect. |
| | Form equation of the tangent with *their* $(x, y)$ and *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ | **DM1** | E.g. $y - \sqrt{2} = -\frac{\sqrt{2}}{2}(x-1)$ if correct. |
| | Obtain equation of tangent $\sqrt{2}y + x = 3$ or exact three-term equivalent | **A1** | E.g. $2y = -\sqrt{2}x + 3\sqrt{2}$. |
| | | **4** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6 | $\frac{\mathrm{d}u}{\mathrm{d}x} = \frac{1}{2}x^{-\frac{1}{2}}$ or $\frac{\mathrm{d}x}{\mathrm{d}u} = 2u$ | **B1** | SOI |
| | Reach an integral of the form $\int A\cos 3u \ \mathrm{d}u$ | ***M1** | OE<br>Condone loss of d$u$. |
| | Obtain $\int 2\cos 3u \ \mathrm{d}u$ | **A1** | OE |
| | Obtain $\frac{2}{3}\sin 3u$ | **A1FT** | OE<br>FT *their* coefficient $A$. |
| | Substitute correct limits correctly in an expression of the form $B\sin 3u$ or $B\sin 3\sqrt{x}$ | **DM1** | $u = \frac{1}{2}\pi$ and $u = \frac{1}{4}\pi$,<br>$x = \frac{1}{4}\pi^2$ and $x = \frac{1}{16}\pi^2$. |
| | Obtain answer $-\frac{2}{3} - \frac{1}{3}\sqrt{2}$ | **A1** | Or exact two-term equivalent.<br>Accept, e.g., $-\frac{2}{3}\left(1+\frac{1}{\sqrt{2}}\right)$.<br>ISW |
| | | **6** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7 | Square $x + iy$ and equate real and imaginary parts to 3 and $-20\sqrt{7}$ respectively | ***M1** | Allow use of $a+bi$ or similar throughout. |
| | Obtain equations $x^2 - y^2 = 3$ and $2xy = -20\sqrt{7}$ | **A1** | OE |
| | Eliminate one variable correctly and find an equation in the other | **DM1** | Attempt to find $x^2 - y^2$ [= 3] and $(x^2 + y^2)^2$ [= $53^2$] instead. |
| | Obtain $x^4 - 3x^2 - 700 = 0$ or $y^4 + 3y^2 - 700 = 0$, or three-term equivalents | **A1** | Allow $x^2 - y^2 = 3$ and $x^2 + y^2 = 53$ instead. |
| | Obtain answers $\pm\left(2\sqrt{7} - 5i\right)$ | **A1** | Accept $\sqrt{28}$. |
| | | **5** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(a) | Sketch $y = x^3$ and $y = 4 - 2x$ and justify the given statement | **B1** | Sketch must show all four quadrants.<br>May also sketch $y = x^3 + 2x$ and $y = 4$, $y = x^3 - 4$ and $y = -2x$, or $y = 4 - x^3$ and $y = 2x$.<br>Need to see a statement about one point of intersection, or a cross, a circle or a dotted line. |
| | | **1** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(b) | **EITHER:**<br>Express $x_{n+1} = \frac{3x_n^3 + 4}{4x_n^2 + 2}$ as $x = \frac{3x^3 + 4}{4x^2 + 2}$ | **(M1** | |
| | Rearrange $x = \frac{3x^3 + 4}{4x^2 + 2}$ to $x^3 = 4 - 2x$ with full and correct working | **A1)** | **AG** |
| | **OR:** | | |
| | Rearrange $x^3 = 4 - 2x$ to $x = \frac{3x^3 + 4}{4x^2 + 2}$ | **(M1** | |
| | Express $x = \frac{3x^3 + 4}{4x^2 + 2}$ as $x_{n+1} = \frac{3x_n^3 + 4}{4x_n^2 + 2}$ after full and correct working | **A1)** | **AG** |
| | Available marks | **2** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(c) | Calculate the values of a relevant expression or pair of expressions at $x = 1$ and $x = 2$ | **M1** | $f(x) = x^3 - 4 + 2x$:<br>$f(1) = -1 < 0$ $f(2) = 8 > 0$.<br><br>Or comparing $x^3$ and $4 - 2x$:<br>$x^3 = 1$ and $4 - 2x = 2$, $1 < 2$<br>$x^3 = 8$ and $4 - 2x = 0$, $8 > 0$.<br><br>Or $f(x) = \frac{3x^3 + 4}{4x^2 + 2} - x$:<br>$f(1) = 0.16\ldots > 0$ $f(2) = -0.44\ldots < 0$.<br><br>Or comparing $\frac{3x^3 + 4}{4x^2 + 2}$ and $x$:<br>$\frac{3x^3 + 4}{4x^2 + 2} = 1.16\ldots$ $x = 1$, $1.16\ldots > 1$<br>$\frac{3x^3 + 4}{4x^2 + 2} = 1.55\ldots$ $x = 2$, $1.55\ldots < 2$.<br><br>Allow if a smaller range is used provided there is a sign change within that range |
| | Complete the argument correctly with correct calculated values | **A1** | |
| | | **2** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(d) | Use the iterative formula correctly at least twice | **M1** | |
| | Obtain final answer 1.18 | **A1** | |
| | Show sufficient iterations to 5 dp to justify 1.18 to 2 dp<br>or show there is a sign change in the interval (1.175, 1.185) | **A1** | 1, 1.16667, 1.17724, 1.17909<br>1.5, 1.28409, 1.20434, 1.18441, 1.18042<br>2, 1.55556, 1.30937, 1.21188, 1.18603, 1.18073, 1.17973<br>Condone minor differences in final figures. |
| | | **3** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 9(a) | State or imply the form $\frac{A}{3x+1}+\frac{Bx+C}{x^2+4}$ | **B1** | |
| | Use a correct method for finding a constant | **M1** | |
| | Obtain one of $A = 9$, $B = -4$ and $C = 0$ | **A1** | Allow maximum M1A1 for one or more 'correct' values after B0. |
| | Obtain a second value | **A1** | |
| | Obtain a third value | **A1** | |
| | | **5** | |
| 9(b) | Use the correct method to find the first two terms of the expansion of $(3x+1)^{-1}$ or $(x^2+4)^{-1}$ or $\left(1+\frac{1}{4}x^2\right)^{-1}$ | **M1** | E.g. $1-3x$, or $\frac{1}{4}-\frac{1}{16}x^2$ or $1-\frac{1}{4}x^2$. |
| | Obtain correct unsimplified expansions up to the term in $x^3$ of each partial fraction | **A1 FT** | The FT is on $A$, $B$ and $C$,<br>e.g. $A\left(1-3x+9x^2-27x^3\right)+(Bx+C)\frac{1}{4}\left(1-\frac{1}{4}x^2\right)$. |
| | | **A1 FT** | |
| | $9-28x+81x^2-\frac{971}{4}x^3$ | **A1** | OE<br>Do not ignore, e.g., multiplication through by 4.<br>Condone if in reverse order. |
| | | **4** | |
| 9(c) | $\lvert x\rvert < \frac{1}{3}$ or $-\frac{1}{3} < x < \frac{1}{3}$ | **B1** | Must be a clear conclusion. |
| | | **1** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10 | **EITHER:**<br>Separate variables correctly | **(B1** | Condone missing integrals or missing d$x$, d$y$, but not both. |
| | Obtain term $4\ln(y+3)$ | **B1** | Condone omission of brackets if recovered later. |
| | Commence integration by parts and reach $axe^{-2x} - \int be^{-2x}dx$ | **M1** | |
| | Obtain $-\frac{1}{2}xe^{-2x} + \int \frac{1}{2}e^{-2x}dx$ | **A1** | |
| | Complete integration by parts and obtain $-\frac{1}{2}xe^{-2x} - \frac{1}{4}e^{-2x}[+c]$ | **A1** | |
| | Use $x = 0$, $y = -2$ to evaluate a constant or as limits in a solution containing terms of the form $a\ln(y+3)$, $bxe^{-2x}$ and $ce^{-2x}$ | **M1** | |
| | Obtain correct answer in any form | **A1** | E.g. $4\ln(y+3) = -\frac{1}{2}xe^{-2x} - \frac{1}{4}e^{-2x} + \frac{1}{4}$. |
| | Obtain $y = \exp\left(-\frac{1}{8}xe^{-2x} - \frac{1}{16}e^{-2x} + \frac{1}{16}\right) - 3$ | **A1)** | OE<br>ISW once correct form is seen. |
| | **OR:**<br>**Alternative Method for Question 10** | | |
| | Separate variables correctly | **(B1** | Condone missing integrals or missing d$x$, d$y$ but not both |
| | Obtain term $\ln(y+3)$ | **B1** | Condone omission of brackets if recovered later |
| | Commence integration by parts and reach $axe^{-2x} - \int be^{-2x}dx$ | **M1** | |
| | Obtain $-\frac{1}{8}xe^{-2x} + \int \frac{1}{8}e^{-2x}dx$ | **A1** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10 | Complete integration by parts and obtain $-\frac{1}{8}x\mathrm{e}^{-2x}-\frac{1}{16}\mathrm{e}^{-2x}[+c]$ | **A1** | |
| | Use $x = 0$, $y = -2$ to evaluate a constant or as limits in a solution containing terms of the form $a\ln(y+3)$, $bx\mathrm{e}^{-2x}$ and $c\mathrm{e}^{-2x}$ | **M1** | |
| | Obtain correct answer in any form | **A1** | E.g. $\ln(y+3)=-\frac{1}{8}x\mathrm{e}^{-2x}-\frac{1}{16}\mathrm{e}^{-2x}+\frac{1}{16}$. |
| | Obtain $y=\exp\left(-\frac{1}{8}x\mathrm{e}^{-2x}-\frac{1}{16}\mathrm{e}^{-2x}+\frac{1}{16}\right)-3$ | **A1)** | OE<br>ISW once correct form is seen |
| | Available marks | **8** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(a) | Use a correct method to form an equation for line $t$ | **M1** | Allow one arithmetic error. |
| | Obtain $\mathbf{r}=\begin{pmatrix}4\\-1\\2\end{pmatrix}+\lambda\begin{pmatrix}-5\\-2\\3\end{pmatrix}$ | **A1** | OE<br>Must have $\mathbf{r}=\ldots$ or $\begin{pmatrix}x\\y\\z\end{pmatrix}=\ldots.$<br>May use $B\begin{pmatrix}-1\\-3\\5\end{pmatrix}$ in place of $A$. |
| | | **2** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(b) | Carry out correct process for evaluating the scalar product of $\begin{pmatrix}-3\\-4\\5\end{pmatrix}$ and *their* $\begin{pmatrix}-5\\-2\\3\end{pmatrix}$ | **M1** | E.g. $(-3 \times -5) + (-4 \times -2) + (5 \times 3)$<br>or $15 + 8 + 15$<br>or 38.<br>Allow one slip. |
| | Using the correct process for the moduli, divide the scalar product by the product of the moduli and evaluate the inverse cosine of the result | **M1** | |
| | Obtain answer 29.3° or 0.512$^{c}$ | **A1** | Allow greater accuracy, 29.33387…. |
| | | **3** | |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(c) | **EITHER:**<br>Find $\overrightarrow{AQ}$ (or $\overrightarrow{QA}$) for a general point $Q$ on $s$, e.g. $\begin{pmatrix} -2-3\mu \\ 2-4\mu \\ 3+5\mu \end{pmatrix}$ | **(B1** | |
| | Calculate the scalar product of $\overrightarrow{AQ}$ and the direction vector for $s$, and equate to 0 | ***M1** | |
| | Solve and obtain correct solution, e.g. $\mu = -\frac{13}{50}$ | **A1** | |
| | Carry out method to calculate $AQ$ | **DM1** | |
| | Obtain answer 3.69 | **A1)** | Or better, e.g. $\sqrt{\frac{681}{50}}$. |
| | **OR:** | | |
| | Find $\overrightarrow{AQ}$ (or $\overrightarrow{QA}$) for a general point $Q$ on $s$, e.g. $\begin{pmatrix} -2-3\mu \\ 2-4\mu \\ 3+5\mu \end{pmatrix}$ | **(B1** | |
| | Use a correct method to express $AQ^2$ (or $AQ$) in terms of $\mu$ | ***M1** | |
| | Obtain a correct equation in any form | **A1** | E.g. $AQ^2 = (-2-3\mu)^2 + (2-4\mu)^2 + (3+5\mu)^2$. |
| | Carry out a complete method for finding its minimum | **DM1** | E.g. $-6(-2-3\mu)-8(2-4\mu)+10(3+5\mu)=0$, $\mu = -\frac{13}{50}$. |
| | Obtain answer 3.69 | **A1)** | Or better, e.g. $\sqrt{\frac{681}{50}}$. |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(c) | **OR:** | | |
| | Calling (2, 1, 5) $P$, state $\overrightarrow{PA}$ (or $\overrightarrow{AP}$) in component form, e.g. $\begin{pmatrix} 2 \\ -2 \\ -3 \end{pmatrix}$ | **(B1** | |
| | Use a scalar product to find the projection of $\overrightarrow{PA}$ (or $\overrightarrow{AP}$) onto $s$ | ***M1** | |
| | Obtain correct answer $\frac{13}{\sqrt{50}}$ | **A1** | OE |
| | Use Pythagoras to find the perpendicular | **DM1** | $d = \sqrt{AP^2 - AQ^2} = \sqrt{2^2 + 2^2 + 3^2 - \left(\frac{13}{\sqrt{50}}\right)^2}$ |
| | Obtain answer 3.69 | **A1)** | Or better, e.g. $\sqrt{\frac{681}{50}}$. |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(c) | **OR:** | | |
| | Calling (2, 1, 5) $P$, state $\overrightarrow{PA}$ (or $\overrightarrow{AP}$) in component form, e.g. $\begin{pmatrix}2\\-2\\-3\end{pmatrix}$ | **(B1** | |
| | Calculate the vector product of $\overrightarrow{PA}$ and the direction vector for $s$ | ***M1** | |
| | Obtain correct answer, e.g. $\begin{pmatrix}-22\\-1\\-14\end{pmatrix}$ | **A1** | |
| | Divide modulus of the product by that of the direction vector | **DM1** | E.g. $\frac{\sqrt{22^2+1^2+14^2}}{\sqrt{3^2+4^2+5^2}}$. |
| | Obtain answer 3.69 | **A1)** | Or better, e.g. $\sqrt{\frac{681}{50}}$. |
| | Available marks | **5** | |

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