Comparison of key skills specifications 2000/2002 with 2004 standardsX015461July 2004Issue 1



Mark Scheme (Results)

October 2020

Pearson Edexcel GCE Mathematics

Pure 1 Paper 9MA0/01

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**General Marking Guidance**

* All candidates must receive the same treatment.  Examiners must mark the first candidate in exactly the same way as they mark the last.
* Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
* Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
* There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
* All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme.  Examiners should also be prepared to award zero marks if the candidate’s response is not worthy of credit according to the mark scheme.
* Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
* When examiners are in doubt regarding the application of the mark scheme to a candidate’s response, the team leader must be consulted.
* Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

**EDEXCEL GCE MATHEMATICS**

**General Instructions for Marking**

1. The total number of marks for the paper is 100.
2. The Edexcel Mathematics mark schemes use the following types of marks:

* **M** marks: method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
* **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
* **B** marks are unconditional accuracy marks (independent of M marks)
* Marks should not be subdivided.

1. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

* bod – benefit of doubt
* ft – follow through
* the symbol will be used for correct ft
* cao – correct answer only
* cso - correct solution only. There must be no errors in this part of the question to obtain this mark
* isw – ignore subsequent working
* awrt – answers which round to
* SC: special case
* oe – or equivalent (and appropriate)
* dep – dependent
* indep – independent
* dp decimal places
* sf significant figures
* 🞸 The answer is printed on the paper
* The second mark is dependent on gaining the first mark

1. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
2. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.

If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

1. Ignore wrong working or incorrect statements following a correct answer.
2. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

**General Principles for Further Pure Mathematics Marking**

(*But note that specific mark schemes may sometimes override these general principles*)

**Method mark for solving 3 term quadratic:**

**1. Factorisation**

, leading to 

, leading to 

**2. Formula**

Attempt to use the correct formula (with values for *a*, *b* and *c*)

**3. Completing the square**

Solving :  , leading to

**Method marks for differentiation and integration:**

**1. Differentiation**

Power of at least one term decreased by 1. 

**2. Integration**

Power of at least one term increased by 1. 

**Use of a formula**

Where a method involves using a formula that has been learnt, the advice given in recent examiners’ reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values but may be lost if there is any mistake in the working.

**Exact answers**

Examiners’ reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **1 (a)** |  | M1  A1 | 1.1b  1.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(b)** | Substitutes into  to give | M1 | 1.1b |
| Explains that is substituted into  and you multiply the result by 2 | A1ft | 2.4 |
|  | **(2)** |  |
| **(5 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:** Attempts the binomial expansion with  and obtains the correct structure for term 3 **or** term 4.

Award for the correct coefficient with the correct power of *x*. Do not accept  notation for coefficients.

For example look for term 3 in the form  or 

**A1:** Correct (unsimplified) expression. May be implied by correct simplified expression

**A1:** 

Award if there are extra terms (even if incorrect).

Award if the terms are listed 

**(b)**

**M1:** Score for substituting into  to obtain  or equivalent such as 

Alternatively award for substituting into **both sides** and making a connection between the

two sides by use of an = or  .

E.g. following through on their expansion

Also implied by  for a correct expansion

It is not enough to state substitute into '' the expansion'' or just the rhs ''''

**A1ft:** Requires a full (and correct) **explanation** as to how the expansion can be used to estimate 

E.g. Calculates and multiplies by 2.

This can be scored from an incorrect binomial expansion or a binomial expansion with more terms.

The explanation could be mathematical. So is acceptable.

SC: For 1 mark, M1,A0 score for a statement such as ''substitute into both sides of part (a) and make  the subject''

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **2** |  | M1 | 1.1b |
|  | dM1 | 2.1 |
|  | A1 | 1.1b |
|  |  | **(3)** |  |
| **(3 marks)** | | | |
| **Notes:** | | | |

**M1:** Takes logs of both sides and uses the power law on **each** side.

Condone a missing bracket on lhs and slips.

Award for any base including ln but the logs must be the same base.

**dM1:** A full method leading to a value for *p*.

It is dependent upon the previous M mark and there must be an attempt to change the subject of the equation in the correct order.

Look for  condoning slips.

You may see numerical versions E.g. 

Use of incorrect log laws would be dM0. E.g 

**A1:** awrt 81.6 following a correct method. Bracketing errors can be recovered for full marks

A correct answer with no working scores 0 marks. The demand in the question is clear.

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There are alternatives:

E.g. A starting point could be 

but the first M mark is still for using the power law correctly on each side

In such a method the dM1 mark is for using **all** log rules correctly and proceeding to a value for *p*.

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Using base 4 or 5

E.g. 

The M mark is not scored until 

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|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **3 (a)** | = | M1 | 1.1b |
| = | A1 | 1.1b |
|  | **(2)** |  |
| **(b)** | States | M1 | 1.1b |
| Explains that as *OC* is parallel to *AB*, so *OABC* is a trapezium. | A1 | 2.4 |
|  | **(2)** |  |
| **(4 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:** Attempts to subtract either way around. If no method is seen it is implied by two of .

**A1:**  or  but not 

**(b)**

**M1:** Compares their with by stating **any one of**

* 
* 
*  or vice versa

This may be awarded if *AB* was subtracted ''the wrong way around'' or if there was one numerical slip

**A1:** Afull explanation as to why *OABC* is a trapezium.

Requires fully correct calculations, so part (a) must be 

It requires a reason and minimal conclusion.

Example 1:

, therefore *OC* is parallel to *AB* so *OABC* is a trapezium

Example 2:

A trapezium has one pair of parallel sides.As , they are parallel, so 🗸.

Example 3

As , *OC* and *AB* are parallel, so proven

Example 4

Accept as , they are parallel so true

Note: There are two definitions for a trapezium. One stating that it is a shape with one pair of parallel sides, the other with **only one** pair of parallel sides. Any calculations to do with sides *OA* and *CB* in this question may be ignored, even if incorrect.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **4 (a)** | Either attempts  Or attempts  and substitutes in | M1 | 3.1a |
| oe | A1 | 1.1b |
|  | **(2)** |  |
| **(b)** | Attempts | M1, dM1 | 1.1b  1.1b |
|  | A1 | 2.1 |
|  | **(3)** |  |
| **(5 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:** For either attempting to solve . Look for an attempt to multiply by the  leading to a value for *x*.

Or score for substituting in  in  FYI 

The method for finding should be sound, but you can condone slips.

**A1:** 

**(b)**

**M1:** For an attempt at fully substituting into . Condone slips but the expression must have a correct form. E.g.  where *a* and *b* are positive constants.

**dM1:** Attempts to multiply **all** terms on the numerator and denominator by  to create a fraction  where both  and  are linear expressions. Condone 

**A1:** Reaches via careful and accurate work. Implied by  following correct work.

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Methods involving  may be seen. The scheme can be applied in a similar way

FYI 

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **5 (a)** | Uses | M1 | 3.1b |
| Uses | M1 | 3.4 |
| = 62.8 (km h -1 ) | A1 | 1.1b |
|  | **(3)** |  |
| **(b)** | Uses | M1 | 3.1b |
| Uses  or | M1 | 3.4 |
| = 86.7 (km h -1 ) | A1 | 1.1b |
|  | **(3)** |  |
| **(6 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:**  Translates the problem into maths using *n*th term  and attempts to find *d*

Look for either  or an attempt at  condoning slips

It is implied by use of  Note that  is M0

**M1:** Uses the model to find the fastest speed the car can go in 3rd gear using  or equivalent.

This can be awarded following an incorrect method of finding ''*d*''

**A1:** 62.8 km/ h Lack of units are condoned. Allow exact alternatives such as 

**(b)**

**M1:** Translates the problem into maths using *n*th term  and attempts to find *r*

It must use the 1st and 6th gear and not the 3rd gear found in part (a)

Look for either  o.e. or  condoning slips.

It is implied by stating or using 

**M1:** Uses the model to find the fastest speed the car can go in 5th gear using  or  o.e.

This can be awarded following an incorrect method of finding ''*r*''

A common misread seems to be finding the fastest speed the car can go in 3rd gear as in (a).

Providing it is clear what has been done, e.g.  it can be awarded this mark.

**A1:** awrt 86.7 km/h Lack of units are condoned. Expressions must be evaluated.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **6 (a)** |  | B1 | 1.1b |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
|  |  |  |  |
| **(b)** | or awrt 7.24 | B1ft | 2.2a |
|  |  | **(1)** |  |
| **(c)** |  | M1 | 3.1b |
|  | A1 | 1.1b |
| Either 13:14 or 1:14 pm or 13 hours 14 minutes after midnight. | A1 | 3.2a |
|  | **(3)** |  |
| **(7 marks)** | | | |
| **Notes:** | | | |

**(a)**

**B1:**  only.

**M1:** Proceeds to a value of  from OR 

It is implied by either awrt 1.11 (radians) or 63.4 (degrees)

**A1:** 

**(b)**

**B1ft:** Deduces that the maximum temperature is  or awrt 7.24 Remember to isw

Condone a lack of units. Follow through on their value of *R* so allow 

**(c)**

**M1:** An complete strategy to find *t* from 

Follow through on their 1.107 but the angle must be in radians.

It is possible via degrees but only using 

**A1:** awrt 

**A1:** The question asks for the time of day so accept either 13:14, 1:14 pm, 13 hours 14 minutes after midnight, 13h 14, or 1 hour 14 minutes after midday. If in doubt use review

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It is possible to attempt parts (b) and (c) via differentiation but it is unlikely to yield correct results.

 scores M1 A1 A1

 they can score M1 A0 A1 (SC)

A value of  implies the minimum value has been found and therefore incorrect method M0.

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|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **7** | Attempts equation of line  Eg Substitutes into  and finds *m* | M1 | 1.1b |
| Equation of *l* is | A1 | 1.1b |
| Attempts equation of *C*  Eg Attempts to use the intercept within the equation  in order to find *a* | M1 | 3.1a |
| Equation of *C* is  or | A1 | 1.1b |
| Region *R* is defined by  o.e. | B1ft | 2.5 |
|  | **(5)** |  |
| **(5 marks)** | | | |
| **Notes:** | | | |

The first two marks are awarded for finding the equation of the line

**M1:** Uses the information in an attempt to find an equation for the line *l*.

E.g. Attempt using two points: Finds *m*  and uses of one of the points in their  or equivalent to find *c*. Alternatively uses the intercept as shown in main scheme.

**A1:**  seen or implied.This alone scores the first two marks. Do not accept 

It must be in the form *y* = ... but the correct equation can be implied from an inequality. E.g. .

The next two marks are awarded for finding the equation of the curve

**M1:** A complete method to find the constant *a* in  or the constants *a*, *b* in .

An alternative to the main scheme is deducing equation is of the form  and setting and solving a pair of simultaneous equations in *a* and *b* using the point ( 2, 13) the gradient being 0 at *x* = 2. Condone slips. Implied by  or 

FYI the correct equations are  and

**A1:**  or equivalent such as, .

Do not accept  or just  for the A1 but may be implied from an inequality

or from an attempt at the area, E.g. 

**B1ft:** Fully defines the region *R*. Follow through on their equations for *l* and *C*.

Allow strict or non -strict inequalities as long as they are used consistently.

E.g. Allow for example '''' ''''

Allow the inequalities to be given separately, e.g. . Set notation may be used so  is fine but condone with or without any of 

Incorrect examples include '' **or** '', 

Values of *x* could be included but they must be correct. So  is fine

If there are multiple solutions mark the final one.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **8** | Any equation involving an exponential of the correct form.  See notes | M1 | 3.1b |
| (where *A* and *k* are positive constants) | A1 | 1.1b |
|  | **(2)** |  |
| **(2 marks)** | | | |
| **Notes:** | | | |

**M1:** Any equation of the correct form, involving *n* and an exponential in *t*.

So allow for example , ,  condoning 

Condone an intermediate form where *n* has not been made the subject.

E.g Allow  but also condone 

**A1:** E.g.  There is no requirement to state that *A* and *k* are positive constants

Note that the two constants need to be different.

Mark the final answer so  followed by  o.e. such as is M1 A0

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You may see solutions that don't include ''e''.

These are fine so you can include versions of  using the same marking criteria as above

FYI  so 

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|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **9(a)** |  |  |  |
| Differentiates to | M1  A1 | 1.1b  1.1b |
| \* | A1\* | 2.1 |
|  |  | **(3)** |  |
| **(b)** | States roots of | B1 | 1.1b |
| Substitutes one *x* value to find a *y* value | M1 | 1.1b |
| Stationary points are  and | A1 | 1.1b |
|  |  | **(3)** |  |
| **(c)** | (i) Range o.e. such as | B1ft | 2.5 |
| (ii) For   * Either attempting to find  and identifying this as the **lower bound** * Or attempting to find  and identifying this as the **upper bound** | M1 | 3.1a |
| Range | A1 | 1.1b |
|  |  | **(3)** |  |
| **(9 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:** Attempts the product rule and uses 

If candidate states  with  it can be implied by their 

If they just write down an answer without working award for 

They may multiply out first . Apply in the same way condoning slips

Alternatively attempts the quotient rule on  with and 

**A1:** A correct which may be unsimplified.

Via the quotient rule you can award for  o.e.

**A1\*:** Proceeds correctly to given answer showing all necessary steps.

The or  must be present at some point in the solution

This is a ''show that'' question and there must not be any errors. All bracketing must be correct.

Allow a candidate to move from the **simplified** unfactorised answer of 

to the given answer in one step.

Do not allow it from an **unsimplified** 

Allow the expression / bracketed expression to be written in a different order.

So, for example, is OK

**(b)**

**B1:** States or implies  (as the roots of )

**M1:** Substitutes one *x* value of their solution to  in f(*x*) to find a *y* value.

Allow decimals here (3sf). FYI, to 3 sf, = 29.6 and 

Some candidates just write down the *x* coordinates but then go on in part (c) to find the ranges using the *y* coordinates. Allow this mark to be scored from work in part (c)

**A1:** Obtains  and as the stationary points. This must be scored in (b). Remember to isw after a correct answer. Allow these to be written separately. E.g. 

Extra solutions, e.g. from  will be penalised on this mark.

**(c)(i)**

**B1ft:** For a correct range written using correct notation.

Follow through on 2 🞩their minimum ''*y*'' value from part (b), providing it is negative.

Condone a decimal answer if this is consistent with their answer in (b) to 3sf or better.

Examples of correct responses are , ,

**(c)(ii)**

**M1:** See main scheme. Follow through on  for the upper bound.

**A1:** Range o.e. such as but must be exact

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **10 (a)** | oe | B1 | 1.1b |
| Full substitution | M1 | 1.1b |
| Finds correct limits e.g. | B1 | 1.1b |
| \* | A1\* | 2.1 |
|  | **(4)** |  |
| **(b)** |  | M1 | 1.1b |
| Correct PF. | A1 | 1.1b |
|  | dM1  A1ft | 3.1a  1.1b |
| Uses limits  with some correct ln work leading to  E.g. | M1 | 1.1b |
|  | A1 | 2.1 |
|  |  | **(6)** |  |
| **(10 marks)** | | | |
| **Notes: Mark (a) and (b) together as one complete question** | | | |

**(a)**

**B1: **or exact equivalent. E.g. **, **

**M1:** Attempts a full substitution of , including **** to form an integrand in terms of *u*. Condone slips but there should be an attempt to use the correct substitution on the denominator.

**B1**: Finds correct limits either states  or sight of embedded values as limits to the integral

**A1\*:** Clear reasoning including one fully correct intermediate line, including the integral signs, leading to the given expression ignoring limits. So B1, M1, B0, A1 is possible if the limits are incorrect, omitted or left as 5 and 10.

**(b)**

**M1:** Uses correct form of PF leading to values of *A* and *B*.

**A1:** Correct PF (Not scored for just the correct values of *A* and *B*)

**dM1:** This is an overall problem solving mark. It is for using the correct PF form and integrating using lns.

Look for 

**A1ft:** Correct integration for their with or without modulus signs

**M1:** Uses their 2 and 3as limits, with at least one correct application of the addition law or subtraction law leading to the form or . PF's must have been attempted. Condone bracketing slips. Alternatively changing the *u*'s back to *x*'s and use limits of 5 and 10.

**A1:** Proceeds to. Answers without working please send to review.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **11 (a)** | Solves  and simultaneously to find *x* or *y* E.g. | M1 | 3.1a |
| Either  Or | A1 | 1.1b |
| Attempts to find the angle *AOB* in circle  Eg Attempts  to find  then | M1 | 3.1a |
| Angle *AOB* = rads (3sf) \* | A1\* | 2.1 |
|  |  | **(4)** |  |
| **(b)** | Attempts  = 56.48 | M1 | 1.1b |
| Attempts to find angle *AXB* or *AXO* in circle  (see diagram)  E.g.  (Note *AXB* =1.03 rads) | M1 | 3.1a |
| Attempts + | dM1 | 2.1 |
| = 89.7 | A1 | 1.1b |
|  |  | **(4)** |  |
| **(8 marks)** | | | |
| **Notes:** | | | |

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**(a)**

**M1:** For the key step in an attempt to findeither coordinate for where the two circles meet.

Look for an attempt to set up an equation in a single variable leading to a value for *x* or *y*.

**A1:**  (or )

**M1:** Uses the radius of the circle and correct trigonometry in an attempt to find angle *AOB* in circle 

E.g. Attempts  to find  then 

Alternatives include to find  then 

And 

**A1\*:** Correct and careful work in proceeding to the given answer. Condone an answer with greater accuracy.

Condone a solution where the intermediate value has been truncated, provided the trig equation is correct.

E.g. 

Condone a solution written down from awrt  (without the need to shown any calculation.)

E

**(b)**

**M1:** Attempts to usethe formula **** with  and 

The formula may be embedded. You may see which is fine for this M1

**M1:** Attempts to use a correct method in order to find angle *AXB* or *AXO* in circle 

Amongst many other methods are  and 

Note that many candidates believe this to be 0.635. This scores M0 dM0 A0

**dM1:** A full and complete attempt to find the perimeter of the region.

It is dependent upon having scored both M's.

**A1:** awrt 89.7

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(a)

M1: For the key step in attempting to find all lengths in triangle *OAX*, condoning slips

A1: All three lengths correct

M1: Attempts cosine rule to find  then 

A1\*: Correct and careful work in proceeding to the given answer

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|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **12 (a)** | States or uses | B1 | 1.2 |
|  | M1 | 2.1 |
| \* | A1\* | 2.1 |
|  |  | **(3)** |  |
| **(b)** |  |  |  |
|  | M1 | 3.1a |
|  | A1 | 1.1b |
| Also | M1 | 2.1 |
|  | A1 | 1.1b |
| Deduces | B1 | 2.2a |
|  |  | **(5)** |  |
| **(8 marks)** | | | |
| **Notes:** | | | |

**(a) Condone a full proof in *x* (or other variable) instead of  here**

**B1:** States or uses  Do not accept with the **** missing

**M1:** For the key step in forming a single fraction/common denominator

E.g. . Allow if written separately 

Condone missing variables for this M mark

**A1\*:** Shows careful work with all necessary steps shown leading to given answer. See scheme for necessary

steps. There should not be any notational or bracketing errors.

**(b) Condone  instead of *x*'s here**

**M1:** Uses part (a), cancels or factorises out the  term, to establish that one solution is found when

.

You may see solutions where  or .

As long as they don't state or  this is acceptable

**A1:** 

**M1:** For the key step in realising that  has a period of  and a second solution can be found by solving . The sight of can imply this mark provided the step has been seen. Using reciprocal functions it is for realising that  has a period of 

**A1:**  Withhold this mark if there are additional values in the range (0,180) but ignore values outside.

**B1:** Deduces that a solution can be found from . Ignore additional values here.

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Solutions with limited working. The question demands that candidates show all stages of working.

SC: 

They have shown some working so can score B1, B1 marked on epen as 11000

**Alt 1- Right hand side to left hand side**

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **12 (a)** | States or uses | B1 | 1.2 |
|  | M1 | 2.1 |
| \* | A1\* | 2.1 |
|  |  | **(3)** |  |

**Alt 2- Works on both sides**

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **12 (a)** | States or uses  or | B1 | 1.2 |
|  | M1 | 2.1 |
| States a conclusion E.g.  ''HENCE TRUE'',  ''QED''  or  o.e. (condone = for ) | A1\* | 2.1 |
|  |  | **(3)** |  |

**Alt (b)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
|  |  | M1 | 3.1a |
|  | A1 | 1.1b |
| Also | M1 | 2.1 |
|  | A1 | 1.1b |
| Deduces | B1 | 2.2a |
|  |  | **(5)** |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **13 (a)** | Uses the sequence formula  once with | M1 | 1.1b |
| Finds four consecutive terms and sets equal to (oe) | M1 | 3.1a |
| \* | A1\* | 2.1 |
|  | **(3)** |  |
| **(b)** | States that when , all terms are the same and concludes that the sequence does not have a period of order 3 | B1 | 2.3 |
|  |  | **(1)** |  |
| **(c)** | Deduces the repeating terms are | B1 | 2.2a |
|  |  | M1 | 3.1a |
|  |  | A1 | 1.1b |
|  |  | **(3)** |  |
| **(7 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:** Applies the sequence formula seen once.

This is usually scored in attempting to find the second term. E.g. for  or 

**M1:** Attempts to find  and sets . Condone slips.

Other methods are available. E.g. Set , work backwards to find  and equate to 

There is no requirement to see either  or any of the labels. Look for the correct terms in the correct order.

There is no requirement for the terms to be simplified

FYI and so 

**A1\*:** Proceeds to the given answer with accurate work showing all necessary lines. See MS for minimum

**(b)**

**B1:** States that when , all terms are the same and concludes that the sequence does not have a

period of order 3.

Do not accept ''the terms just repeat'' or ''it would mean all the terms of the sequence are 2''

There must be some reference to the fact that it does not have order 3. Accept it has order 1.

It is acceptable to state  and state that the sequence does not have order 3

**(c)**

**B1:** Deduces the repeating terms are 

**M1:** Uses a clear strategy to find the sum to 80 terms. This will usually be found using multiples of the first three terms.

For example you may see = 

or  = 

For candidates who find in terms of *k* award for  or 

If candidates proceed and substitute  into to get  then all 3 marks are scored.

**A1:** 

...............................................................................................................................................................................

Note: Be aware that we have seen candidates who find the first three terms correctly, but then find

 which gives the correct answer

but it is an incorrect method and should be scored B1 M0 A0

...........................................................................................................................................................................

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **14 (a)** | Uses the model to state  (for positive constant *c*) | B1 | 3.1b |
|  | Uses with their and | M1 | 2.1 |
|  | \* | A1\* | 2.2a |
|  |  | **(3)** |  |
| **(b)** | and integrates with one side ''correct'' | M1 | 2.1 |
|  | A1 | 1.1b |
| Uses | M1 | 1.1b |
| Uses | M1 | 3.4 |
| or exact equivalent | A1 | 3.3 |
|  | **(5)** |  |
| **(c)** | Uses the equation of their model and proceeds to a limiting value for *t* E.g. | M1 | 3.4 |
| For times up to and including seconds | A1ft | 3.5b |
|  |  | **(2)** |  |
| **(10 marks)** | | | |
| **Notes:** | | | |

**(a)**

**B1:** Uses the model to state  (for positive constant *c*).

Any ''letter'' is acceptable here including *k*.

Note that is B0 unless they state that *c* is a negative constant.

**M1:** For an attempt to use with their and 

Allow for an attempt to use with their and (Any constant is fine)

There is no requirement to use the correct formula for the volume of a sphere for this mark.

**A1\***: Proceeds to the given answer with an intermediate line equivalent to 

If candidate started with they must provide a minimal explanation how . E.g is a constant so replace  with 

It is not necessary to use the full formula for the volume of a sphere, eg allow  but if it

has been quoted it must be correct. So using can potentially score 2 of the 3 marks.

(**b)**

**M1:** For the key step of separating the variables correctly AND integrating one side with at least one index correct. The integral signs do not need to be seen.

**A1:** Correct integration E.g.  or equivalent. The  is not required for this mark.

This may be awarded if *k* has been given a value.

**M1:** Uses the initial conditions to find a value for the constant of integration 

If a constant of integration is not present, or *k* has been given a pre defined value, then only the first two marks can be awarded in part (b)

The mark may be awarded if the equation has been adapted incorrectly. E.g. each term cube rooted.

**M1:** Uses the second set of conditions with their value of to find *k*

This may be awarded if the equation has been adapted incorrectly. E.g. each term cube rooted.

**A1:** Obtains any correct equation for the model.

E.g.  or exact equivalent such as .

ISW after sight of a correct answer. Condone recurring decimals e.g.  for 

Do not award if **only the** rounded/truncated decimal equivalents to say  is used.

**(c)**

**M1:** Recognises that the model is only valid when  **and uses this to find *t***. Condone 

Award for an attempt to find the value of *t* when *r* =0. See scheme.

It must be from an equation of the form which give + ve values of *t*.

**A1ft:** Allow valid for times up to (and including) seconds, 5.71 seconds. Allow or 

There is no requirement for the left hand side of the inequality, 0

States invalid for times greater thanseconds, 5.71 seconds.

Follow through on their equation so allow  as long as this value is greater than 5 ( *t* = 5 is one of the values in the question)

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **15 (a)** |  | M1  A1 | 3.1a  1.1b |
| Full method to get in terms of *x* using | M1 | 1.1b |
| \* | A1\* | 2.1 |
|  | **(4)** |  |
| **(b)** | o.e. | M1  A1 | 1.1b  1.1b |
| States that when  when  **AND** when  giving a point of inflection when | A1 | 2.4 |
|  | **(3)** |  |
| **(7 marks)** | | | |
| **Notes:** | | | |

**(a)**

**M1:** Attempts to differentiate implicitly. Eg.  or 

You may well see an attempt 

When a candidate writes  the mark is scored for 

**A1: Correct differentiation **

Allow also **** or  amongst others

**M1:** Full method to get in terms of *x*using 

**A1\*:** Proceeds correctly to the given answer of 

**(b)**

**M1:** Attempts to differentiate the given expression using the product or quotient rule.

For example look for a correct attempt at with 

If no method is seen or implied award for 

Using the product rule award for 

**A1:** Correct **simplified**  o.e. such as 

Alternatively score for showing that when a correct (unsimplified) 

Or for substituting into an unsimplified but correct and showing that it is 0

**A1:** Correct explanation with a minimal conclusion and correct second derivative.

See scheme.

It can be also be argued from , and  provided the conclusion states that the point of inflection is at 

Alternatively substitutes values of *x* either side of  and at , into , finds all three values and makes a minimal conclusion.

A different method involves finding  and showing that  and when 

FYI  when 

Alternative part (a) using arctan

M1: Sets  where ... could be 1

A2: 

A1\*:  showing correct intermediate step and no errors.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **16** | Sets up the contradiction and factorises:  There are positive integers *p* and *q* such that | M1 | 2.1 |
| If true then  or  **Award for deducing either of the above statements** | M1 | 2.2a |
| Solutions are  or  Award for one of these | A1 | 1.1b |
| This is a contradiction as there are no integer solutions hence  there are no positive integers *p* and *q* such that | A1 | 2.1 |
|  | **(4)** |  |
| **(4 marks)** | | |
| **Notes:** | | | |

**M1:** For the key step in setting up the contradiction and factorising

**M1:** For deducing that for *p* and *q* to be integers then either  or must be true.

**Award for deducing either of the above statements**.

You can ignore any reference to  as this could not occur for positive *p* and *q*.

**A1:** For correctly solving one of the given statements,

For  candidates only really need to proceed as far as  to show the contradiction.

For  candidates only really need to find either *p* or *q* to show the contradiction.

Alt for  candidates could state that  if  are positive integers.

**A1:** For a complete and rigorous argument with both possibilities and a correct conclusion.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **16 Alt 1** | Sets up the contradiction, attempts to make  or  the subject and states that either is even(\*) , or that (or *q*) is odd (\*\*)  Either There are positive integers *p* and *q* such that  with \* or \*\*  Or There are positive integers *p* and *q* such that  with \* or \*\* | M1 | 2.1 |
| Sets and expands | M1 | 2.2a |
| Proceeds to an expression such as | A1 | 1.1b |
| States  This is a contradiction as must be a multiple of 4  Or must be an integer  And concludes  there are no positive integers *p* and *q* such that | A1 | 2.1 |
|  | **(4)** |  |

**Alt 2**

An approach using odd and even numbers is unlikely to score marks.

To make this consistent with the Alt method, score

M1: Set up the contradiction and start to consider one of the cases below where *q* is odd, 

Solutions using the same variable will score no marks.

M1: Set up the contradiction and start to consider BOTH cases below where *q* is odd, 

No requirement for evens

A1: Correct work and deduction for one of the two scenarios where *q* is odd

A1: Correct work and deductions for both scenarios where *q* is odd with a final conclusion

|  |  |  |
| --- | --- | --- |
| Options | Example of Calculation | Deduction |
| *p* (even) *q* (odd) |  | One less than a multiple of 4 so cannot equal 25 |
| *p* (odd) *q* (odd) |  | Three more than a multiple of 4 so cannot equal 25 |

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