

Semester Two Examination, 2022

Question/Answer booklet

MATHEMATICS  
SPECIALIST  
UNITS 3&4

**SOLUTIONS**

Section Two:  
Calculator-assumed

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WA student number: In figures |  |  |  |  |  |  |  |  |  |  |

In words

Your name

|  |  |
| --- | --- |
| Number of additional answer booklets used (if applicable): |  |

## Time allowed for this section

Reading time before commencing work: ten minutes

Working time: one hundred minutes

## Materials required/recommended for this section

***To be provided by the supervisor***

This Question/Answer booklet

Formula sheet (retained from Section One)

***To be provided by the candidate***

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener,  
correction fluid/tape, eraser, ruler, highlighters

Special items: drawing instruments, templates, notes on two unfolded sheets of A4 paper, and up to three calculators, which can include scientific, graphic and Computer Algebra System (CAS) calculators, are permitted in this ATAR course examination

## Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

## Structure of this paper

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Section | Number of questions available | Number of questions to be answered | Working time (minutes) | Marks available | Percentage of examination |
| Section One: Calculator-free | 7 | 7 | 50 | 49 | 35 |
| Section Two: Calculator-assumed | 12 | 12 | 100 | 91 | 65 |
|  | | |  | **Total** | 100 |

## Instructions to candidates

1. The rules for the conduct of examinations are detailed in the school handbook. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet preferably using a blue/black pen.  
Do not use erasable or gel pens.

3. You must be careful to confine your answers to the specific question asked and to follow any instructions that are specific to a particular question.

4. Show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Incorrect answers given without supporting reasoning cannot be allocated any marks. For any question or part question worth more than two marks, valid working or justification is required to receive full marks. If you repeat any question, ensure that you cancel the answer you do not wish to have marked.

5. It is recommended that you do not use pencil, except in diagrams.

6. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

7. The Formula sheet is not to be handed in with your Question/Answer booklet.

Section Two: Calculator-assumed 65% (91 Marks)

This section has**twelve** questions. Answer **all** questions. Write your answers in the spaces provided.

Working time: 100 minutes.

Question 8 (8 marks)

The distribution of the weights of loaves of rye bread produced by a bakery has a mean and standard deviation of g and g respectively. Quality control frequently take random samples of white loaves from the bakery and calculate the mean weight of each sample.

(a) Describe the expected distribution of these sample means. (3 marks)

|  |
| --- |
| Solution |
| Sample means will be normally distributed with a mean of g and standard deviation of g. |
| Specific behaviours |
| ✓ states normally distributed  ü states mean  ü calculations standard deviation |

Further production checks are made if the mean weight of a sample is less than a prescribed minimum value of g.

(b) Over the course of the next random samples, how many times would you expect that further production checks need to be made? (2 marks)

|  |
| --- |
| Solution |
| Hence, expect to make further checks times. |
| Specific behaviours |
| ✓ calculates probability  ü calculates expected number of times |

Quality control has to reduce the sample size from to and change the prescribed minimum value so that the frequency of further production checks remains the same.

(c) Determine the prescribed minimum value for the mean weight of a sample required for this change. (3 marks)

|  |
| --- |
| Solution |
| New standard deviation of sampling distribution will be .  Required -score for is . Hence  The prescribed minimum value should be changed to g. |
| Specific behaviours |
| ✓ calculations new standard deviation  ü obtains -score for required probability  ü calculates required value |

Question 9 (6 marks)

The position vectors of points and are and respectively.

(a) Determine the vector equation of line that passes through and . (1 mark)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ü correct vector equation |

The vector equation of curve is .

(b) Determine the Cartesian equation of curve . (2 marks)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ✓ expresses in terms of or  ü obtains Cartesian equation (any form) |

(c) Determine the position vector(s) of the point(s) where curve meets line . (3 marks)

|  |
| --- |
| Solution |
| Equating coefficients:  Solving simultaneously gives .  Hence position vector of point is . |
| Specific behaviours |
| ✓ forms simultaneous equations  ü solves equations for and/or  ü substitutes to obtain correct position vector |

Question 10 (9 marks)

Let and .

(a) State the domain and range of . (3 marks)

|  |
| --- |
| Solution |
| For natural domain we require .  Hence and .  Range will be all values of where . Hence |
| Specific behaviours |
| ✓ indicates at least one required condition / inequality  ü correct domain  ü correct range |

(b) Determine and state its range. (3 marks)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ✓ indicates appropriate steps to obtain inverse  ü correct inverse (factored or expanded form)  ü correct range |

(c) Determine an expression for and state the domain for which the composite function is defined. (3 marks)

|  |
| --- |
| Solution |
| For the domain we require |
| Specific behaviours |
| ✓ correct expression for composite function  ü indicates required condition  ü correct domain |

Question 11 (6 marks)

The position vector of a particle moving in the Cartesian plane at time seconds is given by

(a) Show that the particle is moving at a constant speed. (2 marks)

|  |
| --- |
| Solution |
| Velocity:  Speed: |
| Specific behaviours |
| ✓ differentiates to obtain velocity vector  ü uses Pythagorean identity to show speed is constant |

(b) Calculate the scalar product of the position vector and the velocity vector of the particle and interpret the result. (2 marks)

|  |
| --- |
| Solution |
| Hence the position vector and the velocity vector of the particle are always perpendicular. |
| Specific behaviours |
| ✓ calculates scalar product  ü interprets result of scalar product |

(c) Determine the acceleration vector of the particle when its position vector is . (2 marks)

|  |
| --- |
| Solution |
| Hence . |
| Specific behaviours |
| ✓ differentiates to obtain acceleration vector  ü correct acceleration vector at given position |

Question 12 (9 marks)

The mean and standard deviation of a random sample of physics teachers working in a region was and years respectively. The sample was taken to construct a confidence interval for the mean age of such teachers.

(a) State two reasons why it is appropriate to assume the approximate normality of the distribution of the sample mean for this data. (2 marks)

|  |
| --- |
| Solution |
| Sampling is random and sample size of is large (i.e., exceeds ). |
| Specific behaviours |
| ✓ states sampling is random  ü states sample size is large |

(b) State another assumption required to construct a valid confidence interval. (1 mark)

|  |
| --- |
| Solution |
| - sample standard deviation is a good estimate for the population standard deviation.  - sample values are independent of each other |
| Specific behaviours |
| ✓ states one valid assumption |

(c) Construct a confidence interval for the mean age of physics teachers working in the region. (3 marks)

|  |
| --- |
| Solution |
| Interval: |
| Specific behaviours |
| ✓ standard deviation of sampling distribution  ü correct expression for confidence interval  ü correct confidence interval |

(d) Based on another random sample, the confidence interval for the mean age of art teachers employed in the same region was calculated to be . Given that the standard deviation of the sample was years, determine the size of the sample.

(3 marks)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ✓ margin of error  ü correct equation for sample size  ü correct sample size |

Question 13 (8 marks)

<EFOFEX>
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</EFOFEX>Let , where is a constant, and region   
be the area between the -axis and the curve .  
  
All dimensions are in centimetres.

(a) When , determine the volume of revolution when is rotated about the -axis.

(5 marks)

|  |
| --- |
| Solution |
| Expressions for inner and outer curves:  When . |
| Specific behaviours |
| ✓ expressions for inner and outer curves  ü obtains maximum value of  ü indicates correct definite integral for inner or outer volume  ü indicates appropriate method to obtain required volume  ü obtains correct volume |

(b) When is rotated about the -axis, the volume of revolution is cm3.  
Determine the value of . (3 marks)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ü correct definite integral for volume  ü obtains expression for volume in terms of  ✓ forms equation and solves for |

Question 14 (8 marks)

Consider the complex number .

(a) Let be the subset of the complex plane that satisfies .

(i) Sketch the subset . (3 marks)

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|  |
| --- |
| Solution |
| . See diagram. |
| Specific behaviours |
| ✓ indicates two given points  ü draws their perpendicular bisector  ü indicates correct side of line |

(ii) Determine the exact minimum value of in . (2 marks)

|  |
| --- |
| Solution |
| Require minimum distance from to . |
| Specific behaviours |
| ✓ indicates value as distance  ü correctly calculates distance |

(b) Sketch the subset of the complex plane that satisfies the equation .

(3 marks)

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|  |
| --- |
| Solution |
| Arguments of from and must be opposite. |
| Specific behaviours |
| ✓ indicates arguments from and opposite  ü correct rays in complex plane  ü indicates ray ends not included |

Question 15 (7 marks)

Let be a rectangle in the complex plane, where is the origin. The points and represent the complex numbers and respectively, where and .

(a) Draw a labelled sketch of the rectangle in the complex plane. (2 marks)

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</EFOFEX>

|  |
| --- |
| Solution |
| See diagram |
| Specific behaviours |
| ✓ rectangle, in second quadrant  ü in first quadrant, |

(b) Determine the complex number represented by . (1 mark)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ü correct complex number for |

Rectangle is rotated about in an anticlockwise direction to .

(c) Determine in exact Cartesian form the complex numbers represented by the points and . (4 marks)

|  |
| --- |
| Solution |
| Let so that multiplying any complex number by will rotate it anticlockwise in the complex plane. Then |
| Specific behaviours |
| ✓ indicates use of multiplication by complex number for rotation  ü complex number for  ü simplified complex number for  ü simplified complex number for |

Question 16 (8 marks)

The probability that an adult King Charles spaniel of weight kg is a female can be modelled by the logistic equation

(a) Calculate the probability that a spaniel of weight kg is a female. (1 mark)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ✓ correct value |

(b) Sketch the graph of this model on the axes below. (2 marks)

|  |
| --- |
| Solution |
| See graph |
| Specific behaviours |
| ✓ endpoints and logistic 'S' curve  ü point of inflection close to |

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(c) The logistic equation can be written in the form . State the value of and the value of . (2 marks)

|  |
| --- |
| Solution |
| is limiting value as and so .  From defining rule, . |
| Specific behaviours |
| ✓ value of  ü value of |

(d) The sensitivity of the model is defined as the absolute value of the change in for a one-gram increase in the weight of a spaniel. Determine the maximum value of .

(3 marks)

|  |
| --- |
| Solution |
| changing fastest at point of inflection, when .  This rate is in kg, hence . |
| Specific behaviours |
| ✓ indicates where the rate of change is greatest  ü obtains value of at point of inflection  ü correct maximum value of |

Question 17 (7 marks)

(a) Let the complex numbers and . Determine the modulus and argument of in terms of the real constants and .

(2 marks)

|  |
| --- |
| Solution |
| Hence and . |
| Specific behaviours |
| ✓ modulus  ü argument |

(b) Let the complex numbers and . Determine the value(s) of the real constant given that is purely imaginary. (2 marks)

|  |
| --- |
| Solution |
| . |
| Specific behaviours |
| ✓ expresses in real and imaginary parts  ü correct values of |

(c) The complex number is a root of the equation ,  
where and are real non-zero constants.  
  
Determine two roots of the complex equation . (3 marks)

|  |
| --- |
| Solution |
| is a solution, so require square roots of . |
| Specific behaviours |
| ✓ indicates square roots of required  ü one root  ü second root |

Question 18 (7 marks)

A small body is moving in a straight line so that seconds after leaving fixed point its velocity is cm/s and its acceleration cm/s2, where and are constants.

Initially the body is at rest at and its acceleration is cm/s2.

seconds later, its velocity is m/s and its acceleration is m/s2.

(a) Show that . (3 marks)

|  |
| --- |
| Solution |
| When and when . Using :  Hence |
| Specific behaviours |
| ✓ obtains value of  ü obtains value of  ü uses to obtain equation |

(b) Determine the exact value of . (4 marks)

|  |
| --- |
| Solution |
| When and so  When and so |
| Specific behaviours |
| ✓ separates variables  ü obtains correct antiderivative  ü evaluates constant of integration  ü obtains exact value of |

Question 19 (8 marks)

Plane contains triangle .

Relative to , the points and have position vectors and respectively.

(a) State the unit vectors and . (1 mark)

|  |
| --- |
| Solution |
|  |
| Specific behaviours |
| ✓ correct unit vectors |

(b) Calculate . (1 mark)

|  |
| --- |
| Solution |
| is the angle between and .  Using CAS, . |
| Specific behaviours |
| ✓ correct angle |

(c) Determine the equation of plane in the form . (2 marks)

|  |
| --- |
| Solution |
| Hence equation of plane is . |
| Specific behaviours |
| ✓ indicates correct normal to plane  ü correct equation of plane (any multiple of ) |

Point with position vector lies in plane and within triangle so that and bisects .

(d) Explain why the values of and must satisfy the equation .

(1 mark)

|  |
| --- |
| Solution |
| For to lie in plane, it must satisfy the equation for plane : |
| Specific behaviours |
| ✓ explains that lies in plane and so must satisfy equation from (c) |

(d) Determine two other equations that the values of and must satisfy and hence, or otherwise, determine vector , giving components rounded to three decimal places.

(3 marks)

|  |
| --- |
| Solution |
| So that (note that is a unit vector):  To have then :  Solving equations and from (d) simultaneously using CAS gives  So that lies in , and so  *NB Other methods exist to determine , such as finding point where the angle bisector intersects and thus obtaining the required unit vector. Beware of erroneous arguments such as the angle bisector will bisect side , etc., but otherwise award one mark for an alternative approach that results in the correct vector. Note that .* |
| Specific behaviours |
| ✓ forms equation using magnitude of  ü forms equation so that is bisector (no simplification required)  ü obtains unit vector as required (3 d.p. for guidance only) |

Supplementary page

Question number: \_\_\_\_\_\_\_\_\_

Supplementary page

Question number: \_\_\_\_\_\_\_\_\_

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