GCE

Further Mathematics A

Y531/01: Pure Core

AS Level

Mark Scheme for June 2025

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 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 available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

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 question 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. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(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 objects 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 the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

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 any way 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 is not 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.**

9.   Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10.   For answers marked by levels of response: Not applicable in F501
To determine the level – start at the highest level and work down until you reach the level that matches the answer
To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

Annotation	Meaning
✔and✘	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

Subject Specific Marking Instructions

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is

sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all

responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
-       if there is nothing written at all in the answer space and no attempt elsewhere in the script
-       OR if there is a comment which does not in any way 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, a picture) which isn't an attempt at the question.
Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. 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 always 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, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c.   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.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words "Determine" or "Show that", or some other indication that the method must be given explicitly.

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, e.g. 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.

d.   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. (The notation 'dep*' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) 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.

e.   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, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

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.

f. We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
   • When a value is **given** in the paper only accept an answer correct to at least as many significant figures as the given value.
   • When a value is **not given** in the paper accept any answer that agrees with the correct value to **3 s.f.** unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
      NB for Specification B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads "2 s.f".

   Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
   Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g. Rules for replaced work and multiple attempts:
   • If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
   • If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
   • if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. 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, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors. If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold "In this question you must show detailed reasoning", or the command words "Show" or "Determine". Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AO	Guidance	
1	**(a)**		$x = 7\cos2.2$ or $y = 7\sin2.2$	**M1**	1.1	Allow for $7\cos\theta$ where θ from an attempt to convert to degrees. Allow for related angle	Note: $\cos 2.2 = -0.5885\ldots$ Sin $2.2=0.8084964\ldots$
			$z = -4.12\ldots$	**A1**	1.1		
			$\ldots + 5.66\text{i}$	**A1**	1.1	Allow answers rounding to $-4.12+5.66\text{i}$ Must be in Cartesian form $(-4.12+5.66\text{i})$ for full marks	$-4.11950782\ldots.+5.6594748\ldots$ i If written as $(\pm4.12, \pm5.66)$ then allow **SC B1** as long as one sign correct
			ALT $\quad\quad x^2 + y^2 = 49$ $\dfrac{y}{x} = \tan 2.2 = -1.3738\ldots$ $x^2 + (-1.3738x)^2 = 49$ $x^2 = 16.97\ldots$	**M1**		Setting up simultaneous equations and substituting to find an equation in x or y only.	Allow errors in substitution for **M1** Allow $x^2 + y^2 = 7$ or $\tan2.2 = \dfrac{x}{y}$ Do not allow $\tan(\dfrac{y}{x}) = 2.2$
			$z = -4.12\ldots$	**A1**		**A0** if any other values given as well unless clearly rejected	
			$\ldots + 5.66\text{i}$	**A1**		**A0** if any other values given as well unless clearly rejected	
				[3]			
	(b)		$(a + b\text{i})^2 = a^2 - b^2 + 2ab\text{i}$	**B1**	1.1	soi in solution	
			$a^2 - b^2 = 1$ and $2ab = 4\sqrt{3}$ (where a and b are real)	**M1**	1.1	Condone loss of exact form for **M1M1A1**	This correct line implies B1 Allow M1 for sign mistake when expanding
			$b = \dfrac{2\sqrt{3}}{a} \Rightarrow a^2 - \left(\dfrac{2\sqrt{3}}{a}\right)^2 = 1$ $\therefore \left(a^2\right)^2 - a^2 - 12 = 0$	**M1**	1.1	Eliminating b or a to obtain 3 term quadratic in a^2 or b^2. Non-zero terms on same side. "= 0" seen or can be implied by solution.	$(a^2)^2$ or a^4. Eliminating a leads to $b^4 + b^2 - 12 = 0$ Factorised forms: $(a^2 - 4)(a^2 + 3)$ or $(b^2 + 4)(b^2 - 3)$
			a real $\Rightarrow a^2 = 4$ only	**A1**	1.1	Or equivalent in b Some indication of root rejection	Evidence could be just the positive value of a^2 appearing, but if both roots appear both must be correct and one must be rejected
			so $\pm(2 + \sqrt{3}\text{i})$ oe only	**A1**	1.1	Allow $2 + \sqrt{3}\text{i}$, $-2 - \sqrt{3}\text{i}$ Not $\pm2 \pm \sqrt{3}\text{i}$. Not $\pm 2 + \sqrt{3}\text{i}$.	Not after loss of exact form unless recovery clear. Independent of previous A mark
				[5]			

Question			Answer	Marks	AO	Guidance	
2	**(a)**		$\mathbf{a.b} = -8 - 18 + 13p = 13p - 26$	**B1**	1.1	Must be simplified correctly	
			$\mathbf{a} \times \mathbf{b} = \begin{pmatrix} 2 \\ -3 \\ 13 \end{pmatrix} \times \begin{pmatrix} -4 \\ 6 \\ p \end{pmatrix} = \begin{pmatrix} -3 \times p - 13 \times 6 \\ 13 \times -4 - 2 \times p \\ 2 \times 6 - -3 \times -4 \end{pmatrix}$	**M1**	1.1	Using formula for cross product. Condone one error (can be implied by 2 of the 3 components given correctly in final answer).	
			$= \begin{pmatrix} -3p - 78 \\ -2p - 52 \\ 0 \end{pmatrix}$	**A1**	1.1	Needs to be simplified correctly	If **M0** then **SCB1** for $\begin{pmatrix} 3p + 78 \\ 2p + 52 \\ 0 \end{pmatrix}$
				[3]			
	(b)		Perpendicular: $(13p - 26 = 0 \Rightarrow)\ p = 2$	**B1FT**	2.2a	Follow through on answer to 2(a)	No working necessary
			Parallel: (need $-3p - 78 = 0$ and $-2p - 52 = 0$ $\Rightarrow$) $p = -26$	**B1FT**	2.2a	Could use scaling, or $\mathbf{a.b} = |\mathbf{a}|\,|\mathbf{b}|$ Allow FT from part (a) as long as the first two components give the same value of p (ignore z component).	**SCB1** (or **B1FT**) for both answers correct but with no indication of which is which. Do not allow **SCB1** if they are incorrectly identified
				[2]			

Question			Answer	Marks	AO	Guidance	
3	**(a)**		$\alpha + \beta = -\dfrac{3}{2}$	**B1**	1.1		
			$\alpha\beta = \dfrac{5}{2}$	**B1**	1.1		
				[2]			
	(b)		$\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$	**M1**	3.1a	Expressing $\alpha^2 + \beta^2$ in terms of the symmetric functions	"Using answers to part a", so some evidence of how these are used is needed
			$= \left(-\dfrac{3}{2}\right)^2 - 2\left(\dfrac{5}{2}\right) = \dfrac{9}{4} - \dfrac{20}{4} = -\dfrac{11}{4}$ oe	**A1**	1.1	-2.75	
			$\dfrac{1}{\alpha} + \dfrac{1}{\beta} = \dfrac{\alpha + \beta}{\alpha\beta}$	**M1**	1.1	Expressing $1/\alpha + 1/\beta$ in terms of the symmetric functions	
			$= \dfrac{\left(-\dfrac{3}{2}\right)}{\left(\dfrac{5}{2}\right)} = -\dfrac{3}{5}$ oe	**A1**	1.1	Exact equivalent only (-0.6)	
				[4]			

Question			Answer	Marks	AO	Guidance	
4	**(a)**	**(i)**	Reflection in the line $y = x$.	**B1**	1.2	Not "mirrored"	
				[1]			
	(a)	**(ii)**	If you carry out the same reflection twice you get back to where you started.	**B1**	2.4	The idea that the second identical reflection undoes the first.	BOD reference to mirror here Must be a geometrical argument B0 if only argument is det(M) = -1
				[1]			
	(b)		Rotation	**M1**	2.2a	Recognising the matrix as a rotation.	
			By $(+)\frac{1}{3}\pi$ (radians) anticlockwise about O.	**A1**	1.1	Angle and sense given. Allow 60° for angle	Allow omissions of O **A0** if includes another transformation as well
				[2]			
	(c)		T_C is represented by **BA**	**M1**	2.2a	Recognising the correct order for the multiplication	**Determine:** Needs some evidence. Could see the correct order of matrices before multiplication
			$= \frac{1}{2}\begin{pmatrix} 1 & -\sqrt{3} \\ \sqrt{3} & 1 \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \frac{1}{2}\begin{pmatrix} -\sqrt{3} & 1 \\ 1 & \sqrt{3} \end{pmatrix}$	**A1**	1.1		If **M0** then **SCB1** for correct answer with no working.
				[2]			

Question			Answer	Marks	AO		Guidance	
5	**(a)**		Circle drawn in the first quadrant	**M1**	1.1			
			Circle has radius and centre $(20 + 15i)$ with a solid circumference and the interior labelled L.	**A1**	1.1	Allow labelled on diagram or in words next to diagram. Ignore lines clearly added by candidates when attempting **(b)** and/or **(c)**.	Allow r=7 to be implied from other points marked on diagram

Allow BOD if not labelled L as long as it is clear the correct region is being identified

Allow BOD if L outside the circle as long as the circle is shaded (or statement such as "inside the circle")

If **M0** then **SCB1** for centre of form $(\pm 20, \pm 15i)$ and radius 7 soi | |
				[2]				
	(b)		Distance from O to centre $= \sqrt{(20^2 + 15^2)} = 25$	**B1**	3.1a	Must be used in solution. Can be implied by sight of 25 in working	BOD centres of the form $(\pm 20, \pm 15i)$	
			$\therefore |z|_{min} = 25 - 7 = 18$ so	**M1**	2.2a	Finding the minimum value of $|z|$ (could be embedded in calculation).		
			$\therefore z = \dfrac{18}{25}(20 + 15i) = \dfrac{72}{5} + \dfrac{54}{5}i$	**A1**	1.1	14.4 + 10.8i Condone answer left as $\dfrac{18}{25}(20 + 15i)$ and ISW once allowable form seen.	If **M0**, **SCB2** in total for correct answer.

Maximum mark with no working shown (other than finding distance of O from the centre) is SCB2. | |

			ALT (Let the origin be O, the centre of the circle C and the closest point be X) The angle between the x-axis and line OC is $\tan^{-1}\frac{15}{20}\,(=0.6435\ldots)$ $$\overrightarrow{XC}=\begin{pmatrix}7\cos 0.6435\\7\sin 0.6435\end{pmatrix}$$	**M1**		Finding angle from origin to centre **and** attempt at finding either the vertical or horizontal distance from centre to closest point	Only one distance needs to be attempted. Must be using a radius of 7
			$$\overrightarrow{XC}=\begin{pmatrix}7\cos 0.6435\\7\sin 0.6435\end{pmatrix}\left[=\begin{pmatrix}5.6\\4.2\end{pmatrix}\right]$$	**A1FT**		Both correct, FT on centres of the form $(\pm 20,\pm 15i)$	$=\begin{pmatrix}\pm 5.6\\\pm 4.2\end{pmatrix}$
			$$\begin{pmatrix}20\\15\end{pmatrix}-\begin{pmatrix}5.6\\4.2\end{pmatrix}=\begin{pmatrix}14.4\\10.8\end{pmatrix}$$ So point is at 14.4+10.8i	**A1**		Not FT here	
			ALT 2 $$y=\frac{3}{4}x$$	**B1**		Finding the equation of the line between O and C	
			$(x-20)^2+(y-15)^2=49$ $(x-20)^2+\left(\frac{3}{4}x-15\right)^2=49$ $x^2-40x+400+\frac{9}{16}x^2-\frac{45}{2}x+225=49$ $\frac{25}{16}x^2-\frac{125}{2}x+576=0$ $25x^2-1000x+9216=0$	**M1**		Solving simultaneous equations which have come from valid attempts at the equation of the straight line OC and the circle equation. Must have eliminated one variable. Might have some errors	Could use $x^2+y^2=18^2$
			$(5x-72)(5x-128)=0$ x=14.4 So point is at 14.4+10.8i	**A1**		If both roots seen for x must both be correct.	
				[3]			

(c)		Either $\tan^{-1}\dfrac{15}{20}\left(=\dfrac{3}{4}\right)$ or $\sin^{-1}\dfrac{7}{25}$ (oe) seen	**M1**	3.1a	Their 25. Might see $\tan^{-1}\dfrac{7}{24}$ or $\cos^{-1}\dfrac{24}{25}$	Arctan (3/4) = 0.6435… Arcsin(7/25) = 0.28379… Allow BOD for sight of 0.644 or 0.284 or degree equivalents 36.87°, 16.263°
		So required angle = $\tan^{-1}\dfrac{3}{4}+\sin^{-1}\dfrac{7}{25}$	**M1**	2.2a	For reference, relevant point is $\dfrac{72}{5}+\dfrac{96}{5}i$ or 14.4 + 19.2i	
		= awrt 0.927 rads	**A1**	1.1	Or 53.1°	If either **M0**, **SCB2** for correct answer.
		ALT Either $\tan^{-1}\dfrac{20}{15}\left(=\dfrac{4}{3}\right)$ or $\sin^{-1}\dfrac{7}{25}$ (oe) seen	**M1**			
		So required angle = $\dfrac{\pi}{2}-\tan^{-1}\dfrac{4}{3}+\sin^{-1}\dfrac{7}{25}$	**M1**			
		= awrt 0.927 rads	**A1**			
		ALT 2 $y = mx$ is a tangent to $(x-20)^2+(y-15)^2 = 49$ Therefore $x^2-40x+400+m^2x^2-30mx+225 = 49$ has a repeated root, hence the discriminant is 0	**M1**		Might see $\tan\theta$ rather than m Setting up a quadratic equation in x and y and considering the discriminant	
		$(40+30m)^2 - 2304(m^2+1) = 0$ $1404m^2 - 2400m + 704 = 0$ $m = {}^4/_3$ or $m = {}^{44}/_{117}$	**M1**		Setting up a quadratic equation in m and solving	
		$m = {}^4/_3$ $\theta = \tan^{-1}\left(\dfrac{4}{3}\right)=0.927$	**A1**			
			[3]			

Question			Answer	Marks	AO	Guidance	
6	**(a)**		$16 + 2\lambda = 3 + \mu$	**M1**	1.1	Equating x, y or z components to derive an equation in λ and μ.	
			$16 + 2\lambda = 3 + \mu$ $-1 - 27\lambda = 10 + 10\mu$ $3 - 19\lambda = -10 + 10\mu$	**A1**	1.1	Any two equations correct.	
			eg $4 + 8\lambda = -20 \Rightarrow 8\lambda = -24 \Rightarrow \lambda = -3$ (subtracting 2nd from 3rd)	**M1**	1.1	Eliminating one unknown to solve for the other.	Could get eg $430 = 101 + 47\mu$ leading to $\mu = 7$. Can be awarded for sight of $\lambda = -3$ or $\mu = 7$
			$\Rightarrow 10\mu = 3 - 19(-3) + 10 = 70 \Rightarrow \mu = 7$ LHS $= 16 + 2(-3) = 16 - 6 = 10$ RHS $= 3 + 7 = 10$	**B1**	1.1	Subbing back to find the other and checking for consistency in the unused equation.	Allow other valid ways of checking for consistency Must see explicit check
			$\therefore \mathbf{OP} = \begin{pmatrix} 16 \\ -1 \\ 3 \end{pmatrix} + (-3)\begin{pmatrix} 2 \\ -27 \\ -19 \end{pmatrix} = \begin{pmatrix} 10 \\ 80 \\ 60 \end{pmatrix}$ so $(10, 80, 60)$	**A1**	1.1	Condone just vector.	$\mathbf{OP} = \begin{pmatrix} 16 \\ -1 \\ 3 \end{pmatrix} + (-3)\begin{pmatrix} 2 \\ -27 \\ -19 \end{pmatrix} = \begin{pmatrix} 10 \\ 80 \\ 60 \end{pmatrix}$
				[5]			
	(b)		$\therefore \left\lvert \mathbf{OQ} \right\rvert_{max} = \sqrt{10^2 + 80^2 + 60^2} = \sqrt{10100}$ (since $\mathbf{OQ} = v\begin{pmatrix} 10 \\ 80 \\ 60 \end{pmatrix}$, $0 \le v \le 1$)	**M1**	3.1a		
			$= 100.498...$ so OQ is probably ≤ 100 but there is a small chance that it is not.	**A1FT**	2.2b	Allow 100.5 for OQ Must follow an answer for 6(a) which gives $OQ > 100$ Allow "high chance that OQ is less than 100" Allow "OQ can be greater than 100" Accept P($OQ \le 100$)=0.995	Note: The probability that $OQ \le 100$ is 0.995037.. Do Not allow "OQ is greater than 100" or "claim is wrong" Some indication that the claim might not be correct
				[2]			

	Question		Answer	Marks	AO		Guidance
7			Basis case: RHS = $20^{52} = 4.50 \times 10^{67}$ LHS = $52! = 8.07 \times 10^{67} > 4.50 \times 10^{67}$ = RHS So $n! > 20^n$ when $n = 52$	**B1**	2.5	BC. The conclusion for LHS>RHS might appear in final statement.	Ignore calculations and statements relating to $n = 51$. Allow $8 \times 10^{67} > 4.5 \times 10^{67}$
			Assume true for $n = k$ so $k! > 20^k$ (where $k \geq 52$)	**M1**	2.1	Setting up inductive hypothesis properly.	
			Then $(k + 1)! = (k + 1) \times k! > (k + 1) \times 20^k$	**M1**	3.1a	Correctly using the inductive hypothesis	Could see: $k! > 20^k$ $(k+1)k! > (k+1)\,20^k$ Allow k to "slip" in 20^k as long as intention is clear
			$> 20 \times 20^k$ since $k + 1 > 20$ since $k \geq 52$ $= 20^{k+1}$	**A1**	2.2a	Must be sufficient justification	Withhold if k slipped
			So true for $n = k \Rightarrow$ true for $n = k + 1$. But true for $n = 52$ so true for all integers $n \geq 52$.	**A1**	2.4	Clear conclusion for inductive process. Must be 52.	A *formal* proof is required for full marks but other *complete* and *correct* proofs can get full marks.
				[5]			

Question			Answer	Marks	AO	Guidance	
8			Vol SF = 40/8 = 5 & reverse of orientation => det**A** = –5	**B1**	3.1a	Could see embedded in equation below	Can allow recovery in equation
			$\begin{vmatrix} 5+a & 5 & 1 \\ 3 & 13+a & 6 \\ a-4 & -20 & -9 \end{vmatrix} = (5+a)((13+a)\times-9-6\times-20)$ $-5(3\times-9-6(a-4))+1(3\times-20-(13+a)(a-4))$	**M1**	1.1	Expanding the determinant Allow sign errors Allow if two of the three minor determinants are correct	
			$= (5+a)(-117-9a+120)-5(-27-6a+24))$ $+(-60-(13a-52+a^2-4a))$ $= (5+a)(3-9a)-5(-3-6a)-8-9a-a^2$ $= 15-45a+3a-9a^2+15+30a-8-9a-a^2$ $= -10a^2-21a+22$	**M1**	1.1	Reduction of determinant to three term quadratic form (could be done in conjunction with "= –5" or "= 5"). Allow sign errors	Must have used correct form of determinant (apart from sign errors)
			$= -5 \Rightarrow 10a^2+21a-27 = 0$	**A1**	1.1	Arriving at correct 3 term quadratic equation in a.	BOD omission of "=0" if correct a values appears
			$a = -3$ since $a = 9/10$ leads to non-integer entries in **A**.	**A1**	3.2a	Must see both correct roots and correct reason for rejection	
			$\begin{pmatrix} 2 & 5 & 1 \\ 3 & 10 & 6 \\ -7 & -20 & -9 \end{pmatrix}\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$	**M1**	1.1	Multiplying their **A** by the position vector of the given point. Must be correct order of multiplication	Must have used a numerical value of a
			$= \begin{pmatrix} 15 \\ 41 \\ -74 \end{pmatrix}$ so image is (15, 41, –74)	**A1**	1.1	Condone position vector as answer.	Must have come from correct equation found correctly. Allow if reason for rejection of a = -9/10 is incorrect or omitted.
				[7]			

Question			Answer	Marks	AO	Guidance	
9	**(a)**		$[z = a + b\mathrm{i}, a, b$ real$]$ $[zz^*] = (a + b\mathrm{i})(a - b\mathrm{i}) = a^2 + b^2$ $\lvert z \rvert^2 = a^2 + b^2$	**B1**	2.1	AG Must see either $(a + b\mathrm{i})(a - b\mathrm{i})$ Or:　$z = a + b\mathrm{i}$ 　　　$z = a - b\mathrm{i}$ 　　　$zz^* = a^2 + b^2$ Allow $\left(\sqrt{(a^2 + b^2)}\right)^2$ for $\lvert z \rvert^2$	BOD lack of explicit equality shown Must clearly attempt both sides
				[1]			
	(b)		$(z = a + b\mathrm{i}, w = c + d\mathrm{i}, a, b, c, d$ real$)$ $\Rightarrow$ LHS $= (ac - bd + (ad + bc)\mathrm{i})^*$ $= ac - bd - (ad + bc)\mathrm{i}$	**M1**	2.1	AG. Setting up proof and finding one side. w and z must be different.	For M1 BOD missing "big brackets"
			RHS $= (a - b\mathrm{i})(c - d\mathrm{i}) = ac - bd - (ad + bc)\mathrm{i}$	**A1**	1.1	Finding other side and completing proof.	Must be complete and correct proof including insertion of all relevant brackets
				[2]			
	(c)		$(10 + 3\mathrm{i})(9 + 4\mathrm{i}) = 90 - 12 + 27\mathrm{i} + 40\mathrm{i}$	**M1**	1.1	Expanding brackets using $\mathrm{i}^2 = -1$	
			$= 78 + 67\mathrm{i}$	**A1**	1.1		**SCB1** for correct answer with no workings.
				[2]			
	(d)		$\therefore v(v^*) = \lvert v \rvert^2 = 78^2 + 67^2 = 10573$	**B1**	1.1	.	
			$= (10 + 3\mathrm{i})(10 - 3\mathrm{i})(9 + 4\mathrm{i})(9 - 4\mathrm{i})$	**M1**	3.1a	Considering $v(v^*)$ as the product of four complex numbers	Could be for awarded for finding $(10 + 3\mathrm{i})(10 - 3\mathrm{i}) = 109$ or $(9 + 4\mathrm{i})(9 - 4\mathrm{i}) = 97$
			$= (100 + 9)(81 + 16) = 109 \times 97$	**A1**	2.2a	No need to assert primality of 109 and 97.	Need to see evidence that they have expressed $v(v^*)$ as the product of four complex numbers.
				[3]			

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