GCE

Mathematics A

H240/03: Pure Mathematics and Mechanics

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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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

11. **Annotations**

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.

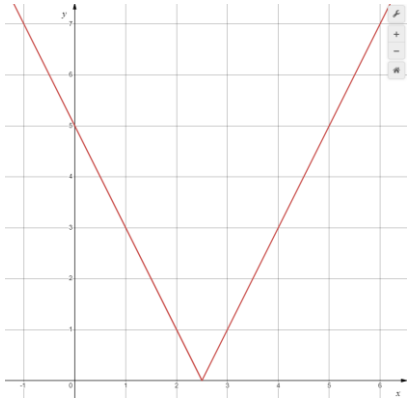
h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some 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)		$\{3\}\left(x\ \{-2\}\right)^2\ \{+5\}$	B3 [3]	1.1 1.1 1.1	**B2** for 2 correct { } components, **B1** for 1 correct { } component must be of the form $\pm a\left(x \pm b\right)^2 \pm c$ with terms simplified. Award **B1** for explicitly stating $a = 3$, **B1** for explicitly stating $b = 2$ and **B1** for explicitly stating $c = 5$	**SC B2** for $3\left(x-2\right)+5$ but no marks for any other non-squared expression
1	(b)		$(2,5)$	B1FT [1]	1.2	Correct answer **or** follow through from their answer to part **(a)** of the form $\pm a\left(x \pm b\right)^2 \pm c$	Allow $x = 2$, $y = 5$ or 2,5
1	(c)		$x = 2$	B1FT [1]	1.1	Correct answer **or** follow through their consistent x-value from parts **(a)** and **(b)**	**Must** be an equation

Question			Answer	Marks	AO	Guidance	
2	(a)			M1	1.1	**M1** for $\frac{1}{(x \pm 4)^3}$ **only (so no misreads)** - need not be an equation for this mark	oe e.g. $(x \pm 4)^{-3}$
			$y = \frac{1}{(x-4)^3}$	A1	1.1	**Must** be an equation of the form $y =$ … but **A0** for only $f(x) = ...$	ISW if expanded either correctly **or** incorrectly
				[2]			
2	(b)		(3,180)	B1	1.1	**B1** for correct **explicit** x-coordinate (so not embedded in a calculation for y)	**B1** for $x = 3$ **B1** for $y = 180$ Allow missing bracket round coordinates
				B1	1.1	**B1** for correct **explicit** simplified y-coordinate (so must be 180)	
				[2]			

Question			Answer	Marks	AO	Guidance	
3	(a)			M1	1.1	V-shape with the cusp on the positive x-axis – need not be symmetrical – this mark can be awarded if V-shape appears in the first quadrant only (so stops at y-axis)	**M0** if V-shape appears in third or fourth quadrants but **condone if RH branch appears in third and fourth quadrants** (BOD that this is a continuation of the line with equation $y = 2x - 5$)
				A1	1.1	Fully correct (so appearing in first **and** second quadrants) with x-intercept labelled as $\frac{5}{2}$ and y-intercept labelled as 5 – need not be symmetrical– condone if appearing in third and fourth quadrants **only as a dashed line.** Ignore horizontal line if drawn at $y = 1$ (assume working for part **(b)**)	Condone $(5,0)$ labelled on the y-axis, and $\left(0,\frac{5}{2}\right)$ labelled on the x-axis
				[2]			

Question			Answer	Marks	AO	Guidance	
3	(b)		$\lvert 2x-5\rvert < 1 \Rightarrow -1 < 2x-5 < 1$ $4 < 2x < 6$	M1	1.1	Re-write as $-1 < 2x-5 < 1$ followed by $a < 2x < b$ with either a or b correct **or** $c < x - \frac{5}{2} < d$ with either c or d correct **or** for either $x > 2$ **or** $x < 3$ (so dealing with one inequality correctly) **or** for both critical values (so 2 **and** 3 www)	$a = 4$, $b = 6$ $c = -\frac{1}{2}, d = \frac{1}{2}$ **M1** for $\lvert 2x-5\rvert < 1$ $\Rightarrow (2x-4)(2x-6) < 0$
			$2 < x < 3$	A1 [2]	1.1	cao – allow as two separate inequalities and allow e.g. '$x > 2$ or $x < 3$'. '$x > 2, x < 3$', '$x > 2$ and $x < 3$' etc.	Ignore incorrect set notation provided the intention of the correct inequalities is clear

Question			Answer	Marks	AO	Guidance	
3	(c)		**DR**				
			$2 < e^{0.1N} < 3$	**M1***	**3.1a**	Use their answer to part **(b)** to re-write in terms of $e^{0.1N}$. Must imply **either** $e^{0.1N} > k_1$ **and** $e^{0.1N} < k_2$ where $k_1 < k_2$ with both positive **or** $e^{0.1N} = k_1$ **and** $e^{0.1N} = k_2$ where $k_1 \neq k_2$ with both positive Allow n, x etc. for N throughout	k_1 and k_2 are their critical values from part **(b)** **M0** for $e^{0.1N} > k_2$ **and** $e^{0.1N} < k_1$ where $k_1 < k_2$
			$10\ln 2 < N < 10\ln 3$	**M1dep***	**1.1**	Correctly take logs of both sides and make N the subject of **both** inequalities/equations e.g. $\frac{\ln 2}{0.1} < N < \frac{\ln 3}{0.1}$, $10 \times 0.693.. < N < 10 \times 1.098...$ (at least to 1 dp), $N = 10\ln 2$ **and** $N = 10\ln 3$	**Must** be correct inequalities/equations for N following through their values of k_1 and k_2 If **M0 M0** then **SC B1** for 6.93… **and** 10.98… **or** $10\ln 2$ **and** $10\ln 3$
			$6.9(314...) < N < 10.9(861...)$ so N = 7, 8, 9 and 10	**A1** **[3]**	**3.2a**	cao www – **must see** at least $6.9... < N < 10.9...$ followed by all four integer values (and no others) stated explicitly **or** correct four integer values stated from correct critical values of 6.9… **and** 10.9… **A0** for 7 < N < 10 oe e.g. 7 – 10	**See Appendix for those using T and I**

Question			Answer	Marks	AO	Guidance	
4	(a)		$\left(\mathrm{f}^{-1}(x)=\right)\ 2x+k$	B1	2.1	For $2x+k$	
			$\left(\mathrm{f}^{-1}\mathrm{g}(x)=\right)\ 2(x^2+kx+5)+k$	M1	1.1	Correct order of operations for the composite function $\mathrm{f}^{-1}\mathrm{g}$	
			Alternative for first two marks in part (a)				
			$(\mathrm{g}(x)=)\ \mathrm{f}\left(4-2kx\right)$	B1		soi	
			$x^2+kx+5=\dfrac{4-2kx-k}{2}$	M1		Condone sign errors only	
			$2(x^2+kx+5)+k=4-2kx$ $\Rightarrow 2x^2+4kx+(6+k)\quad(=0)$	M1*	2.1	Expanding and simplifying to obtain a three-term quadratic expression in x (allow sign errors **only** in the simplification and collection of terms) – all terms must be on the same side and the constant term **must** be a two-term linear expression in k	**Must** come from considering $a\left(x^2+kx+5\right)+bk=4-2kx$ where $a,b\neq 0$ Condone $2x^2+4kx+(6+k)>0$ for **M1** but cannot score the final **A1** mark (as www)
			$(4k)^2-4(2)(6+k)\ \ (>0)$	M1dep*	3.1a	Calculating **correct** discriminant for their 3TQ – allow $4k^2$ recovered to $16k^2$ for **M1** only – do not award this mark if only embedded in quadratic formula	Condone = 0, < 0 etc. for this **M1** mark
			$16k^2-8k-48>0$ $\Rightarrow 2k^2-k-6>0$	A1	2.1	**AG** www – sufficient working must be seen. **Discriminant must have been set > 0 before dividing by 8**	**A0** for setting discriminant = 0 or < 0 (oe wrong inequality) and later replacing with the correct inequality
				[5]			

Question			Answer	Marks	AO	Guidance	
4	(b)		**DR**				
			$(2k+3)(k-2)\ \ (>0)$	**M1**	**1.1**	Correct method for solving their 3 term quadratic which would lead to the critical values of k	See appendix for solving 3TQ
			$k<-\frac{3}{2}, k>2$	**B1**	**1.1**	Correct set of values for k so must be strict inequalities – allow in terms of x and/or k. Ignore any working seen	Condone poor set notation if intention is clear
			$\left\{k : k<-\frac{3}{2}\right\} \cup \{k : k>2\}$	**B1FT**	**2.5**	Correct union set notation for their values of k so **must be in terms of *k*** (and not x). **Must be** of the form $\{k : k<k_1\} \cup \{k : k>k_2\}$ where $k_1<k_2$ **B0** for interval notation **Note that for full marks to be awarded no incorrect working seen**	Note that, for example, $\left\{k<-\frac{3}{2}\right\} \cup \{k>2\}$ and $\left\{k : k<-\frac{3}{2} \cup k : k>2\right\}$ etc. are **B0** **Ignore inclusion of $\in \mathbb{R}$ inside the $\{\ \}$ brackets**
				[3]			

Question			Answer	Marks	AO	Guidance	
5	(a)		$u = \cos x \Rightarrow \mathrm{d}u = -\sin x\,\mathrm{d}x$	B1	2.1	**B1** for $\frac{\mathrm{d}u}{\mathrm{d}x} = -\sin x$ oe	
			$\int \frac{1+\cos x}{\sin x}\mathrm{d}x = -\int \frac{1+u}{1-u^2}\mathrm{d}u$	M1*	1.1	Obtain an integral in terms of u only – must be of the form $\pm\int \frac{\pm 1 \pm u}{\pm 1 \pm u^2}(\mathrm{d}u)$	Allow du missing throughout but **M0** if implying du = dx
			$-\int \frac{1+u}{(1-u)(1+u)}\mathrm{d}u = -\int \frac{1}{1-u}\mathrm{d}u$	M1dep*	3.1a	**Explicit use** of $1-u^2 = (1+u)(1-u)$ **or** $u^2 - 1 = (u+1)(u-1)$ **and** simplify to an integral of the form $\pm\int \frac{1}{\pm 1 \pm u}(\mathrm{d}u)$	
			$= -(-\ln(1-u))\ \ (+c) = \ln(1-\cos x) + c$	A1	2.1	**AG** www – condone $\ln\lvert 1-\cos x\rvert + c$ Allow **A1** for $-\int \frac{1}{1-u}\mathrm{d}u = \ln(1-u) = \ln(1-\cos x) + c$ (**must** see $\ln(1-u)$ as **AG**) However, $\int \frac{1}{u-1}\mathrm{d}u = \ln\lvert\cos x - 1\rvert = \ln(1-\cos x) + c$ is **A0 without further correct working or correct explanation/justification** Note that $\int \frac{1}{u-1}\mathrm{d}u = \ln(\cos x - 1) = \ln(1-\cos x) + c$ is **A0 regardless of any further explanation/justification**	$+c$ must be present in the final given answer e.g. as a minimum $\ln\lvert\cos x - 1\rvert$ $= \ln\lvert(-1)(1-\cos x)\rvert$ $= \ln(1-\cos x) + c$
				[4]			

Question			Answer	Marks	AO	Guidance	
5	(b)		Curve intersects the x-axis at π	B1	3.1a	Possibly implied by later working – condone (use of) 180 (in degrees) **or** $\cos^{-1}(-1)$ (so do not need to see this evaluated to π)	e.g. as a limit on an integral
			$\left[\ln(1-\cos x)\right]_a^{\pi} = a \Rightarrow \ln(1-\cos\pi) - \ln(1-\cos a) = a$	M1*	1.1	Correct use of their upper limit and correct lower limit to form an equation in a only so **must** be of the form $\ln k - \ln(1-\cos a) = a$ following through their value of $k > 0$	Setting equal to a^2 rather than a is **M0**
			$\ln\left(\frac{2}{1-\cos a}\right) = a \Rightarrow \frac{2}{1-\cos a} = e^a$	M1dep*	1.1	Correct use of log laws and correctly remove natural log to form an equation in e^a from $\ln k - \ln(1-\cos a) = a$ following through their $k > 0$ and $k \neq 1$	
			$1-\cos a = 2e^{-a} \Rightarrow \cos a = 1 - 2e^{-a}$ so $a = \cos^{-1}(1-2e^{-a})$ and therefore $a - \cos^{-1}(1-2e^{-a}) = 0$	A1	2.1	**AG –** sufficient working must be shown and must be = 0	allow arccos for $\cos^{-1}$
				[4]			
5	(c)		Let $f(a) = a - \cos^{-1}(1-2e^{-a})$ $f(1.1) = -0.129... < 0$, $f(1.2) = 0.038... > 0$	M1	1.1	Obtain correct value for either f(1.1) **or** f(1.2) to at least 1 sf rot	
			Change of sign indicates that a lies between 1.1 and 1.2	A1	2.4	Both correct values to at least 1 sf rot, 'change of sign' **either** shown **or** stated + conclusion (minimum e.g. 'root')	Allow, for example,' $-0.1 < 0 < 0.03$ therefore $1.1 < a < 1.2$ ' for **A1**
				[2]			

Question			Answer	Marks	AO	Guidance	
5	(d)		$a_2 = 1.16(188...), a_3 = 1.18(725...), a_4 = 1.17(02...)$	B1	1.1	At least the first three values of a_i stated correctly to at least **2** decimal places rot e.g. $a_3 = 1.18$ or $a_3 = 1.19$	Ignore values after the first three
			$a = 1.18$	B1	1.1	cao (must be to exactly **2** decimal places) – final answer must be 1.18 or $a = 1.18$ and not a term of a sequence e.g. $a_9 = 1.18$	**Not dependent on the previous B1. A correct answer without the correct first three terms is B0 B1**
				[2]			

Question			Answer	Marks	AO	Guidance	
5	(e)		The diagram shows that the gradient of all points on the curve $y = \cos^{-1}(1-2e^{-x})$ are negative and therefore the gradient at a lies in the interval $(-\infty, 0)$	B1	2.4	Correct explanation that the **graph** or **diagram** or **curve** (in **Fig. 2**) implies that the **gradient** (either at a or implying all points) is **negative**.	Must mention 'the graph' oe for this mark but mention of **Fig. 1** is **B0**
			As the iterative formula in part **(d)** converged to the value of a this implies that $\left\lvert \frac{d}{dx}\left(\cos^{-1}(1-2e^{-x})\right)\Big\rvert_{x=a} \right\rvert < 1$ and so the gradient of the curve at the point $x = a$ lies in the interval $(-1, 0)$.	B1	2.4	Correct justification that as the iterative formula $\left(a_{n+1} = F(a_n)\right)$ converged to a $\Rightarrow \lvert F'(a) \rvert < 1$. As a minimum **must** state/mention 'convergence' and **EITHER** that the **gradient at *a*** is between -1 and 1 **OR** that the **gradient at *a*** is between -1 and 0 but **only** following a correct explanation that the graph (oe) implies a negative gradient **B2** for 'graph shows negative gradient, and there is convergence, therefore the gradient at a lies in the interval (–1,0)'	Not $\Rightarrow \lvert F'(a_n) \rvert < 1$. **For both marks to be awarded the interval of (–1,0) must be mentioned** Implying that a is between –1 and 1 and not the gradient is **B0** for the second **B** mark
				[2]			

Question			Answer	Marks	AO	Guidance
6	(a)		$A=\frac{C+D}{2}, B=\frac{C-D}{2}$ **and** $\sin C-\sin D=2\cos A\sin B$ $\sin C-\sin D=2\cos\left(\frac{C+D}{2}\right)\sin\left(\frac{C-D}{2}\right)$	**B1** **[1]**	**2.1**	**AG Must** see as a minimum the following three components: [1]: the correct expressions for A **and** B **stated explicitly** (not just in a final answer or as part of trig. expressions) **or** $2\cos\left(\frac{A+B+A-B}{2}\right)\sin\left(\frac{A+B-(A-B)}{2}\right)=2\cos A\sin B$ (if working right to left) [2]: $\sin C-\sin D=2\cos A\sin B$ [3]: the given answer **or both** $\sin C-\sin D=2\cos A\sin B$ **and** $2\cos A\sin B=2\cos\left(\frac{C+D}{2}\right)\sin\left(\frac{C-D}{2}\right)$ (so linking the two parts of the given answer explicitly via the expression $2\cos A\sin B$)

Question			Answer	Marks	AO	Guidance	
6	(b)		$QR = r\tan\theta$ **or** $PR = \dfrac{r}{\cos\theta}$	**B1***	**3.1a**	Can be implied by the correct expression for the area of ΔPQR	**B1** for either expression soi in the area of ΔPQR
			$(\Delta PQR =)\dfrac{1}{2}r(r\tan\theta)$ **or** $\dfrac{1}{2}r\left(\dfrac{r}{\cos\theta}\right)\sin\theta$ $(\Delta PQT =)\dfrac{1}{2}r^2\sin\theta$ **or** (sector $PQST =)\dfrac{1}{2}r^2\theta$	**B1***	**1.1**	**One** correct area expression	
			$\dfrac{1}{2}r^2\sin\theta < \dfrac{1}{2}r^2\theta < \dfrac{1}{2}r^2\tan\theta$	**B1dep***	**2.1**	Correct sandwich inequality in terms of r and θ **-** must be seen at some point in this form and not just as separate inequalities	This result with no working scores **B3** but $\sin\theta < \theta < \tan\theta$ with no working is no marks
			$\sin\theta < \theta < \dfrac{\sin\theta}{\cos\theta} \Rightarrow 1 < \dfrac{\theta}{\sin\theta} < \dfrac{1}{\cos\theta}$	**B1** **[4]**	**2.2a**	**AG –** www sufficient working seen therefore tan must be replaced with $\dfrac{\sin}{\cos}$ and therefore $\sin\theta < \theta < \tan\theta$ $\Rightarrow 1 < \dfrac{\theta}{\sin\theta} < \dfrac{1}{\cos\theta}$ is **B0** **Dependent on all previous B marks**	

Question			Answer	Marks	AO	Guidance	
6	(c)	(i)	$\cos\theta < \frac{\sin\theta}{\theta} < 1$	B1 [1]	3.1a	or $1 > \frac{\sin\theta}{\theta} > \cos\theta$ but not as two separate inequalities (unless correctly brought together)	condone $\frac{\cos\theta}{1} < \frac{\sin\theta}{\theta} < 1$
6	(c)	(ii)	1	B1 [1]	2.2a	Ignore any working seen but **B0** if implying < 1, > 1 etc.	

Question			Answer	Marks	AO	Guidance	
6	(d)		$\left(\frac{f(x+h)-f(x)}{h}=\right)\frac{\sin(x+h)-\sin x}{h}$	B1*	2.1	cao	Denominator must be simplified to h
			$=\frac{2\cos\left(\frac{2x+h}{2}\right)\sin\left(\frac{h}{2}\right)}{h}$	M1dep*	1.1	Using the given expression for $\sin C-\sin D$ from part **(a)** with $C=x+h$ and $D=x$ – allow un-simplified	If not using result from part **(a)** then **M0**
			$\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}=\cos x\times\lim_{h\to 0}\left[\frac{2}{h}\sin\left(\frac{h}{2}\right)\right]$	A1	1.1	Using the result that $\lim_{h\to 0}\cos\left(\frac{2x+h}{2}\right)=\cos x$ to obtain $\cos x\times\lim_{h\to 0}\left[\frac{2}{h}\sin\left(\frac{h}{2}\right)\right]$	Must see limit present for this **A** mark
			$=\cos x\times\lim_{h\to 0}\left[\frac{\sin\left(h/2\right)}{h/2}\right]=\cos x$ (as from part **(c)(ii)** $\lim_{\theta\to 0}\frac{\sin\theta}{\theta}=1$ therefore $\frac{d}{dx}(\sin x)=\cos x$)	A1	2.2a	Re-writing $\frac{2}{h}\sin\left(\frac{h}{2}\right)$ so that the result from part **(c)(ii)** can be applied and obtaining the correct derivative	Or equivalent limit argument e.g. $\lim_{h\to 0}\left(\frac{\sin\left(\frac{1}{2}h\right)}{h}\right)=\frac{1}{2}$
				[4]			

Question			Answer	Marks	AO	Guidance	
6	(e)		The line $\frac{dy}{dx} = \cos\left(\frac{\pi}{2} - x\right)$ is incorrect; (by the chain rule) it should be $\frac{dy}{dx} = -\cos\left(\frac{\pi}{2} - x\right)$	B1 [1]	2.3	Clearly identify the error made e.g. stating that it should be $-\cos\left(\frac{\pi}{2} - x\right)$ or 'the student forgot to multiply $\cos\left(\frac{\pi}{2} - x\right)$ by -1' or '$\sin\left(\frac{\pi}{2} - x\right)$ does not differentiate to $\cos\left(\frac{\pi}{2} - x\right)$' oe **B0** for 'the student forgot to multiply by -1' only **B0** for 'the student forgot to divide $\cos\left(\frac{\pi}{2} - x\right)$ by -1'	Just stating that the derivative should be $-\sin x$ is **B0** If mentioning that 'the student forgot to multiply/include the -1' then it must be clear this is on line 3

Question			Answer	Marks	AO	Guidance	
7	(a)		$(5\mathbf{i}+3\mathbf{j})+(a\mathbf{i}+3b\mathbf{j})=3(2\mathbf{i}-3\mathbf{j})$	M1	3.3	Applying $\mathbf{F}=m\mathbf{a}$ for both components – no misreads of vectors but allow sign errors only	**Must** be $m=3$ for both components. **M0** if including the weight as a force in **F**
			$5+a=6$ **or** $3+3b=-9$	B1	1.1	One correct explicit linear equation not in vector form	This mark can be implied by one correct value for a or b
			$a=1,\quad b=-4$	A1	1.1	ISW if correct a and b stated in working and then miscopied onto the answer lines at the bottom of the PAB	**Correct answers with no working scores full marks. One correct answer with no working scores M0 B1 A0**
				[3]			
7	(b)		$(7\mathbf{i}-6\mathbf{j})=\mathbf{u}+5(2\mathbf{i}-3\mathbf{j})$	B1	3.3	Applying $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ correctly - no misreads of vectors. Or consider two correct linear equations i.e. $7=u_1+5\times 2$ and $-6=u_2-5\times 3$ (condone u for both u_1,u_2)	oe correct expression/equation for **u** if using calculus
			$(\mathbf{u}=)-3\mathbf{i}+9\mathbf{j}$	B1	1.1	Condone given as a column vector	ISW if magnitude of correct **u** is then considered **Correct answer with no working scores full marks**
				[2]			

Question			Answer	Marks	AO	Guidance	
8	(a)		$0.8g - 0.3 - T = 0.8(9.2)$	M1	3.3	Applying N2L for B with correct number of dimensionally correct terms (so allow sign errors only) to obtain an equation in T **only**	This mark is not awarded until all values have been correct substituted into N2L so, for example, must see 0.8 for the mass (and not just m)
			$T = 0.18$	A1 [2]	1.1	cao – must be positive oe e.g. $\frac{9}{50}$	
8	(b)		$0.6g + T - R = 0.6(9.2)$	M1	3.3	Applying N2L for A with correct number of dimensionally correct terms (so allow sign errors only) to obtain an equation in R (and possibly T) **only**. Alternative is to consider N2L for the system which if correct is $0.8g - 0.3 + 0.6g - R = 1.4(9.2)$ (if considering this equation then allow sign errors **only**)	Allow the letter T or their (possibly incorrect) value of T
			$R = 0.54$	A1 [2]	1.1	cao – must be positive oe e.g. $\frac{27}{50}$	

Question			Answer	Marks	AO	Guidance	
9			**DR**				
			$(a=)3+1.2t$	**B1**	**2.1**	Correct expression for the **acceleration** of the particle	**B0** if $s=3+1.2t$
			$3+1.2t=15$	**M1***	**1.1**	Sets their linear expression for a equal to 15	For reference $t=10$
				M1*	**1.1**	Attempt to integrate expression – at least three terms with correct t^2 or t^3 term	
			$(s=)2t+\frac{3}{2}t^2+\frac{0.6}{3}t^3\ (+c)$	**A1**	**1.1**	Correct expression for the **displacement** (allow un-simplified)	**A0** if $a=\int v\,\mathrm{d}t$
			Distance travelled = $\left[2t+\frac{3}{2}t^2+\frac{0.6}{3}t^3\right]_0^{10}=2(10)+\frac{3}{2}(10)^2+\frac{0.6}{3}(10)^3$	**M1dep***	**3.4**	Correct use of limits with **their** positive value of t – must see as a minimum all three values (either simplified **or** un-simplified), for example, if correct then simplified is $20+150+200$. No consideration of lower limit of zero is required but if considered then must be correct, for example, $2(10)+\frac{3}{2}(10)^2+\frac{0.6}{3}(10)^3-2(0)+\frac{3}{2}(0)^2+\frac{0.6}{3}(0)^3$ (so incorrect bracketing) is **M0** (as **DR**) **M0** for $20+150+200+c$ unless $c=0$ is explicitly stated (so not just implied by seeing 370 as a final answer)	A correct answer of 370 does **not** imply this mark **This M mark is dependent on both previous M marks**
			370 (m)	**B1** **[6]**	**2.1**	No justification that $v>0$ for all values of t is required for full marks. Ignore any working seen for this mark but full marks can only be awarded for a completely correct solution	

Question			Answer	Marks	AO	Guidance	
10	(a)		$AG \times 4g = 47.04$ or $(AG =)\dfrac{47.04}{4g}$ or $4g \times 1.2 = 47.04$	B1 [1]	3.1b	Taking moments about A for the rod's weight – allow $\dfrac{47.04}{4 \times 9.8}$ oe (so using 9.8 for g) but **B0** for only $\dfrac{47.04}{39.2}$ oe **B0** for $AB \times 4g = 47.04$ or similar	**AG – www but need not see 1.2 explicitly stated**
10	(b)		$2 \times \dfrac{4}{5}T = 47.04$ or $2 \times \dfrac{4}{5}T = 1.2 \times 4g$ $T = 29.4$ (N)	M1 A1 [2]	3.3 1.1	Taking moments about A for the rod – **M1** for $2 \times \dfrac{4}{5}T = 47.04$ **or** $2 \times T\sin 53 = 47.04$ **or** $2 \times \dfrac{3}{5}T = 47.04$ **or** $2 \times T\cos 53 = 47.04$ **only** (or $1.2 \times 4g$ for 47.04) cao exact e.g. $\dfrac{147}{5}$ **or** awrt 29.4	Allow use of 53 or better (53.1301…) for θ - note that e.g. $2 \times T\sin 37 = 47.04$ or $2 \times T\cos 37 = 47.04$ (therefore using the complementary angle) is **M1**

Question			Answer	Marks	AO	Guidance	
10	(c)		$X = \pm'29.4'\times\frac{3}{5}$ or $\pm'29.4'\times\cos 53$ $(=\pm 17.64)$	B1FT	3.3	Follow through their value of T **only** Allow use of 53 or better (53.1301…) for θ	X is the horizontal component of the contact force at A
			Resolve vertically or take moments about B or G for the forces acting on the rod to form an equation or an expression for Y	M1*	3.3	Must be the correct number of dimensionally correct terms but allow sign errors and sin/cos confusion **only** – all values must be substituted. If taking moments about B or G allow sin/cos confusion **only**	Y is the vertical contact force at A
			$R(\uparrow): '29.4'\times\frac{4}{5}+Y=4g$ **or** $'29.4'\times\frac{4}{5}=4g+Y$ **or** $\mathfrak{M}(B): 0.8\times 4g = 2Y$ **or** $\mathfrak{M}(G): 0.8\times'29.4'\times\frac{4}{5}=Y\times 1.2$	A1FT	1.1	Correct equation for Y follow through their value of T **only** – if correct then $Y=\pm 15.68$	Allow $\sin 53$ or $\cos 37$ or better for $\frac{4}{5}$
			$\sqrt{17.64^2+15.68^2}$	M1dep*	3.4	Correct use of Pythagoras with their **values** of X and Y which **must** come from equations with the correct number of dimensionally correct relevant terms	Relevant for X requires $'29.4'\times\frac{3}{5}$ **or** $'29.4'\times\frac{4}{5}$ oe **only**
			Magnitude is 23.6 (N)	A1	1.1	awrt 23.6 **or** exact e.g. $\frac{49\sqrt{145}}{25}$ oe	23.60152…
				[5]			

Question			Answer	Marks	AO	Guidance	
11	(a)		$x = 2t$	B1	1.1	Correct expression for the horizontal displacement	oe e.g. $t = 0.5x$
			$-8 = u + (-10)(2)$ **or** $\begin{pmatrix} 2 \\ -8 \end{pmatrix} = \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} + 2\begin{pmatrix} 0 \\ -10 \end{pmatrix}$	M1*	3.4	Applying $v = u + at$ correctly with $v = \pm 8, t = 2$ and $a = \pm 10, \pm 9.8, \pm g$ - for reference if correct then $u =$ 12. **If u = 12 stated from either incorrect or no working, then no further marks can be awarded (so B1 max).** Some candidates are using e.g. $u\sin\theta$ or $u\cos\alpha$ and correctly obtaining $u\sin\theta = 12$ which is **M1**	or other complete method to find an equation/expression for the initial vertical component of the velocity. If using a vector approach ignore horizontal component (unless this is merged with the vertical component in some way)
			$y = '12't + \frac{1}{2}(-10)t^2$	M1dep*	3.3	Applying $s = ut + \frac{1}{2}at^2$ correctly with their value of u and $a = \pm 10, \pm 9.8, \pm g$	
			$y = '12'(\frac{x}{2}) + \frac{1}{2}(-10)(\frac{x}{2})^2$	M1	1.1	Eliminate t using $x = 2t$ to form an equation in y and x only (so must be using their value of u) – **dependent on both previous M marks**	Allow with $a = \pm 10, \pm 9.8, \pm g$
			$y = 6x - 5\left(\frac{x}{2}\right)^2 \Rightarrow y = 6x - 1.25x^2$	A1	2.1	**AG** www - correct simplification to given answer. Note that the correct parametric equations (so scoring the first three marks) followed by $y = 6x - \frac{5}{4}x^2 \Rightarrow y = 6x - 1.25x^2$ then scores **M1 A0** only	Allow verification of correct equation from $x = 2t$ and $y = 12t - 5t^2$ for full marks
				[5]			

Question			Answer	Marks	AO	Guidance	
11	(b)		$\frac{dy}{dx} = 6 - 2.5x$	B1	1.1	Correct derivative of given expression for y	**B1** for $6x - 1.25x^2 = 0$ $\Rightarrow x_{max} = 4.8 \therefore x = \frac{4.8}{2}$
			$6 - 2.5x = 0 \Rightarrow x = 2.4$ **and** substitute in $y = 6x - 1.25x^2$ to find y	M1	1.1	Set their derivative of the form $6 + kx$ (where $k < 0$) equal to zero, solve for x and substitute to find corresponding y	
			Alternative 1 for first two marks in part (b)				
			Apply $v^2 = u^2 + 2as$ vertically or $\mathbf{s} = 1.2\begin{pmatrix}2\\12\end{pmatrix} + \frac{1}{2}\begin{pmatrix}0\\-10\end{pmatrix} \times 1.2^2$	M1		Must use $v = 0, a = \pm 10$ or ± 9.8 or $\pm g$ with **any** non-zero value of u (and possibly t). **If u = 12 stated from either incorrect or no working in part (a), then M1 max**	Or other complete suvat/energy method to find max. height – if using a vector method then condone poor notation and see guidance in part **(a)**
			$0 = 12^2 + 2 \times (-10) \times h$ **or** $h = 12 \times 1.2 + \frac{1}{2} \times (-10) \times 1.2^2$	A1		Correct equation for max. height but allow $a = -10$ or -9.8 or $-g$	Must be a correct scalar equation for this mark
			Alternative 2 for first two marks in part (b)				
			$-1.25x^2 + 6x = -1.25\left[(x - 2.4)^2 - 5.76\right]$	M1		For attempting to complete the square – must be of the form $-1.25\left[(x \pm 2.4)^2 \pm ...\right]$	Or **M1** for $\left(-\frac{b}{2a} =\right) -\frac{6}{2 \times (-1.25)}$
			$= -1.25(x - 2.4)^2 + 7.2$	A1		cao	**A1** for $6(2.4) - 1.25(2.4)^2$
			Maximum height is 7.2 (m)	A1	1.1	www cao e.g. $\frac{36}{5}$ but do not ISW if then finding the distance OP	**Must be 7.2**
				[3]			

Question			Answer	Marks	AO	Guidance	
11	(c)		When $x = 2.5$, $\frac{dy}{dx} = -0.25$ so $\tan\theta = -0.25$	M1	3.1b	Substitute $x = 2.5$ into $y' = 6 + kx$ (where $k < 0$) and equate numerical value to $\tan\theta$	If correct, then $y' = 6 - 2.5x$
			$14(.0^\circ)$ **below the horizontal**	A1	3.2a	Or equivalent e.g. 76 **to the downward vertical**, angle must be positive, and description of direction must be in words so not just on a diagram (bearing only is **A0**)	**or** in radians (0.24497… horizontal **or** 1.3258…vertical) to at least 2 sf
			Vertical component of velocity at $x = 2.5$ is given by $'12' + (-10)(1.25)$	M1*	1.1	Correct method to find vertical component velocity at $x = 2.5$ – must be of the form $u + a \times 1.25$ for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$ **or** for component squared from $v^2 = u^2 + 2 \times a \times \frac{115}{16}$ for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$	If correct, then vertical component is ± 0.5 If using vertical distance, then must be correct e.g. $\frac{115}{16}$ or 7.1875 or 7.19 or 7.2
			Speed is given by $\sqrt{2^2 + ('12' + (-10)(1.25))^2}$	M1dep*	1.1	Correct method to find the speed at $x = 2.5$ - must be of the form $\sqrt{2^2 + (u + a \times 1.25)^2}$ for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$	
			$2.06\,(\mathrm{m\,s^{-1}})$	A1	1.1	awrt 2.06 **or** exact e.g. $\frac{\sqrt{17}}{2}, \sqrt{4.25}$ **- allow from a positive vertical component of 0.5** from $v^2 = u^2 + 2as$	2.061552… **If *u* = 12 stated from either incorrect or no working in part (a), then A0**
				[5]			

Question			Answer	Marks	AO	Guidance	
11	(c)		**Alternative for part (c)**				
			Vertical component of velocity at $x = 2.5$ is given by $'12' + (-10)(1.25)$	**M1***		Correct method to find the vertical component of velocity at $x = 2.5$ – must be of the form $u + a \times 1.25$ for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$ **or** for component squared from $v^2 = u^2 + 2 \times a \times \frac{115}{16}$ for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$	If correct, then vertical component is ± 0.5 If using vertical distance, then must be correct e.g. $\frac{115}{16}$ or 7.1875 or 7.19 or 7.2
			Speed is given by $\sqrt{2^2 + ('12' + (-10)(1.25))^2}$	**M1dep***		Correct method to find the speed at $x = 2.5$ - **must** be of the form $\sqrt{2^2 + (u + a \times 1.25)^2}$ for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$	
			$2.06\,(\mathrm{m\,s^{-1}})$	**A1**		awrt 2.06 **or** exact e.g. $\frac{\sqrt{17}}{2}, \sqrt{4.25}$ - allow from a positive vertical component of 0.5 from $v^2 = u^2 + 2as$	**If *u* = 12 stated from either incorrect or no working in part (a), then neither A mark can be awarded**
			$\tan\theta = (\pm)\frac{0.5}{2}$	**M1dep***		For $\tan\theta = \pm\frac{u + a \times 1.25}{2}$ (or reciprocal) for any non-zero u and $a = \pm g, \pm 10, \pm 9.8$	oe e.g. using positive/negative vertical component from $v^2 = u^2 + 2as$
			$14(.0^\circ)$ **below the horizontal**	**A1**		Or equivalent e.g. 76 **to the downward vertical**, angle must be positive, description of direction must be in words so not just on a diagram (bearing only is **A0**)	**or** in radians (0.24497… horizontal **or** 1.3258…vertical) to at least 2 sf
				[5]			

Question			Answer	Marks	AO	Guidance	
11	**(d)**		The maximum height will be less than the value found in part **(b)**	**B1** **[1]**	**3.5a**	Must mention that the height or the answer to part **(b)** would be less	Ignore all other comments

Question			Answer	Marks	AO	Guidance	
12	(a)		Resolving perpendicular to the plane to form an equation	M1*	3.3	Correct number of dimensionally correct terms – **must be using *m* = 10 for M1**	**Allow sign errors and sin/cos mix only**
			$R + T\sin 30 = 10g\cos 30$	A1	1.1	oe e.g. $R = 49\sqrt{3} - 0.5T$ or $R = 84.8(7048...) - 0.5T$ etc.	R is the normal contact force
			Resolving parallel to the plane to form an equation	M1*	3.3	Correct number of dimensionally correct terms – **must be using *m* = 10 for M1**	**Allow sign errors and sin/cos mix only**
			$T\cos 30 + 10g\sin 30 = F$ **or** $T\cos 30 + 10g\sin 30 = 0.8\times{}'R'$	A1	1.1	oe $F = T\times\frac{\sqrt{3}}{2} + 49$ or $F = 0.866(0254...)T + 49$ etc. **May have replaced *F* with 0.8*R* and be using their (possibly incorrect) *R***	F is the frictional contact force For reference only: $R = 77.4076...$ and $F = 61.92608...$
			$T\cos 30 + 10g\sin 30 = 0.8(10g\cos 30 - T\sin 30)$	M1dep*	3.4	Apply $F = 0.8R$ to obtain an equation in T **only**. A correct value of T to at least 4 significant figures rot can imply this and the next mark www	**A correct equation in *T* implies the first 5 marks**
			$T = \frac{40\sqrt{3} - 50}{5\sqrt{3} + 4}g = 14.9$ (N)	A1	2.1	**AG** – awrt 14.9 www - sufficient working must be shown as answer given – **for this mark we must see either the correct answer to at least 4 significant figures rot or a correct explicit expression for *T* e.g.** $T = \frac{8g\cos 30 - 10g\sin 30}{\cos 30 + 0.8\sin 30}$ **before the given answer of 14.9**	14.925760…
				[6]			

Question			Answer	Marks	AO	Guidance	
12	(a)		**Alternative for part (a) – resolving vertically and horizontally**				
			Resolving vertically to form an equation	**M1***		Correct number of dimensionally correct terms – **must be using *m* = 10 for M1**	**Allow sign errors and sin/cos mix only**
			$F\sin 30 + R\cos 30 = 10g$	**A1**		oe e.g. $F + R\sqrt{3} = 20g$ or $0.8R + R\sqrt{3} = 20g$ etc.	
			Resolving horizontally to form an equation	**M1***		Correct number of dimensionally correct terms	**Allow sign errors and sin/cos mix only**
			$T + R\sin 30 = F\cos 30$	**A1**		oe e.g. $2T + R = F\sqrt{3}$ or $2T + R = 0.8R\sqrt{3}$ etc.	
			$R(0.8\sin 30 + \cos 30) = 10g$ $\Rightarrow T + \frac{10g \times \sin 30}{0.8\sin 30 + \cos 30} = \frac{10g \times 0.8\cos 30}{0.8\sin 30 + \cos 30}$	**M1dep***		Apply $F = 0.8R$ to obtain an equation in T **only**. A correct value of T to at least 4 significant figures rot can imply this and the next mark www	For reference: $R = 77.4076...$ and $F = 61.92608...$
			$T = \frac{40\sqrt{3} - 50}{5\sqrt{3} + 4}g = 14.9$ (N)	**A1**		**AG** – awrt 14.9 www - sufficient working must be shown as answer given – for this mark we **must** see either the correct answer to at least 4 significant figures **or** a correct explicit expression for T e.g. $T = \frac{8g\cos 30 - 10g\sin 30}{\cos 30 + 0.8\sin 30}$ before the given answer of 14.9	14.925760…
				[6]			

Question			Answer	Marks	AO	Guidance	
12	(b)		$4g\sin 30 - F_1 = 4\times 3.5$	M1*	3.1b	Applying N2L for the upper block – **allow sign errors and sin/cos mix only - must be using *m* = 4 for M1** (if correct then $F_1 = 5.6$)	where F_1 is the frictional contact force between the two blocks
			$R_1 = 4g\cos 30$	B1	2.1	Correctly resolve forces perpendicular to the line of contact between the two blocks	where R_1 is the normal contact force between the two blocks
			$4g\sin 30 - 4\times 3.5 = \mu\times 4g\cos 30$ $\left(\Rightarrow 5.6 = \mu\times 4g\cos 30\right)$	M1dep*	3.4	Apply $F = \mu R$ with their F_1 to obtain an un-simplified equation/expression in μ only where R **must be replaced by either** $4g\cos 30$ **or** $4g\cos 60$ **or** $4g\sin 30$ **or** $4g\sin 60$	
			$(\mu =)$ 0.165	A1	1.1	awrt 0.165 or allow exact $\frac{2\sqrt{3}}{21}$	0.16495721…
				[4]			
12	(c)		$(F_{max} =)\ 0.8(10g\cos 30 - 14.9\sin 30)$ $(= 61.9...)$ **or** $\left(F_{max} =\right) 14.9\cos 30 + 10g\sin 30$ $(= 61.9...)$	B1*	3.1b	Correct expression for the maximum frictional force between the lower block and the plane – note that $77.4204...\times 0.8$ is **B1**	If expressions not seen then values must be correct to at least 3 sf $77.4076...\times 0.8$ is **B1**
			(Resultant force down the plane is) $4g\sin 30 - 4\times 3.5 + 14.9\cos 30 + 6g\sin 30$ $(= 47.9...)$ **or** $5.6 + 14.9\cos 30 + 6g\sin 30$ $(= 47.9...)$	B1*	3.1b	Correct expression for the resultant force acting down the plane for the lower block	**Do not penalise if a more accurate correct value of *T* is used (14.925760…)**
			$F_{max} >$ Resultant force down the plane and so therefore the lower block does not move **or** $47.9... - 61.9... = 6a \Rightarrow a < 0$ $\therefore$ doesn't move	B1dep*	3.2a	Correctly show that the lower block does not move **or** correctly showing that *a*, or even 6*a* is negative	Correct values to at least 3 sf rot must be seen for this mark
				[3]			

APPENDIX

Rules for solving quadratics in question 4(b) ONLY
In question **4(b)** candidates are required to solve a 3 term quadratic (3TQ) using **DR** – therefore we must see a correct, complete method for solving this quadratic – the correct answers do not imply the corresponding M mark, for example $2x^2 - x - 6 = 0 \Rightarrow x = 2$ or $x = -\frac{3}{2}$ is **M0**
Rules for factorising: $at^2 + bt + c \Rightarrow (mt+n)(pt+q)$ where $a = mp$ **and** one of $mq + np = b$ **or** $c = nq$ (so when expanding their factorised expression it must give the correct quadratic term and one other term correct of the preceding 3TQ expression/equation) e.g. in question **4b**: $2x^2 - x - 6 = (x+\frac{3}{2})(x-2)$ is **M0** (but the following **B1** for the correct $x < -\frac{3}{2}$ and $x > 2$ can still be awarded) $2x^2 - x - 6 = (2x-3)(x+2)$ is **M1** (when expanded the x^2 and constant terms are correct) Allow correct part factorisation for their 3TQ expression e.g. $2x(x-2) + 3(x-2)$ scores **M1**
Rules for the formula: Must apply the correct formula for their three-term quadratic (no errors even if correct formula is stated) – note that stating the formula (in terms of *a*, *b* and *c*) followed immediately by the corresponding roots is **M0** – we **must** see the formula being applied e.g. $2x^2 - x - 6 = 0 \Rightarrow x = \frac{1 \pm \sqrt{1^2 - 4(2)(-6)}}{2(2)}$. Minimal acceptable working would be $x = \frac{1 \pm \sqrt{49}}{4}$ (so must explicitly see the value of the discriminant) for **M1**
Rules for completing the square The **M1** is not awarded until correctly getting to the stage of $x - \frac{1}{4} = \pm\sqrt{\frac{49}{16}}$ (must include $\pm$ so implying two roots) with no errors (so consistent with applying the formula correctly)

Trial and Improvement in 3(c) – if only the first M mark awarded by main scheme, then for **B2** (so for possibly full marks) allow one of the two following cases (the working below is the minimum required)

Case 1:

$e^{0.1N} < 3 \Rightarrow N < 10.98...$ and $e^{0.1N} > 2$

When $N = 7, e^{0.1\times 7} = 2.0137... > 2$ and when $N = 6, e^{0.1\times 6} = 1.822 < 2$ therefore $N = 7, 8, 9$ and 10

Case 2:

$e^{0.1N} < 3, e^{0.1N} > 2 \Rightarrow N > 6.93...$

When $N = 10, e^{0.1\times 10} = 2.7182... < 3$ and when $N = 11, e^{0.1\times 11} = 3.0041... > 3$ therefore $N = 7, 8, 9$ and 10

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