Markscheme

November 2022

Extended Mathematics

On-screen examination

25 pages

The markscheme abbreviations:

The markscheme may make use of the following abbreviation: **OE** – ‘or equivalent’

• Bullet notation means award 1 mark – see example below

Example 1
.1 mark awarded and corresponding notes are aligned

b	.1 Show clear line of reasoning in the method .2 4	.1 45 and 49 seen **OE** *Ex:* $49 = 45 + x$ .2	**2**

Error Carried Forward (ECF) marks

Errors made at any step of a solution affect all working that follows. In general, **Error Carried Forward (ECF)** marks are awarded after an error.

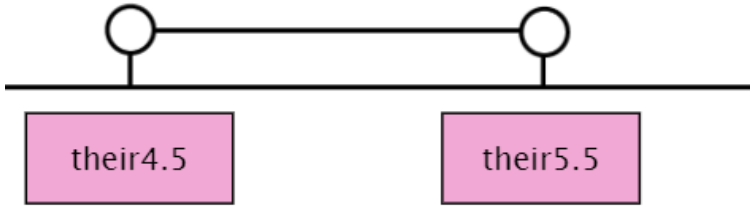
a. **ECF** applies from one part of a question to a subsequent part of the question and also applies within the same part.
b. If an answer resulting from **ECF** is inappropriate (*eg*, negative distances or sin$x$ > 1) then subsequent marks should not be awarded.
c. If a question is transformed by an error into a **simpler question** then **ECF** may not be fully awarded.
d. To award **ECF** marks for a question part, **there must be working present for that part**.
e. **ECF** is only applied to working which is correct. This means that all working subsequent to an error must be checked for accuracy.
f. A misread (**MR**) is an error**. ECF** is normally awarded.

General points

a. As this is an international examination, accept all **alternative forms of notation,** for example 1,9 as 1.9 ; 1,000 or 1.000. However **DO NOT ACCEPT** incorrect mathematical notation x^2 for x^2 unless noted otherwise in the MS
b. Accept notation errors in intermediate steps.
c. Ignore further working after a correct answer **unless** it indicates a lack of mathematical understanding **i.e. if the further working contradict the correct answer,** then that last mark cannot be awarded.
d. In the case when a correct result is obtained using incorrect seen method, do not award the mark for the result.
e. Where candidates have written two solutions to a question, mark the first solution.
f. In the markscheme, equivalent examples of **numerical** and **algebraic** forms or **simplified** answers will generally be written in the notes preceded by **OE** (Or Equivalent) e.g. **OR** 1/2 **OR** 0.5 **OR** **;** **OR** x/2 **OR** ; 0.23 **OR** 23%
g. In the markscheme, information provided in brackets indicate detail that may be seen in a candidate response but is not necessary to award the marks. However, these results need to be seen in the appropriate context to award the mark.
h. Special case marks **SC** can be allocated instead of but not in addition to the marks prescribed in the markscheme.
i. Accept seeing equation not in-line.
j. Calculator screenshots are accepted as working steps. And when a calculator screenshot is taken, accept not seeing the whole operation.
k. In task 2 and 3 where the markscheme is set out in a table then, unless noted otherwise, awarding the highest mark in a category includes all the lower marks in that category. It is probably best to look for the top category mark answer and if you don't find it look at the next mark down.
l. ACCEPT using the correct values regardless their previous result.
m. Candidates will sometimes use methods other than those in the markscheme. Unless the question specifies a method, other correct methods should be marked in line with the markscheme. If in doubt, contact your team leader for advice.
n. Unless noted otherwise, if a note in a part says to accept the answer without working for 1 mark less than total marks, then seeing the correct answer with any acceptable working step, award full marks. Example: If the note in a part worth 3 marks says “4.3(3…) without working award 2 marks”, then seeing any acceptable working step and seeing 4.3(3…) as the answer award the 3 marks.

Q1		Answers	Notes	Total
	a	.1 Correctly write two missing values .2 Correctly write the third missing value	<table><tr><th></th><th>Bus</th><th>Train</th><th>Car</th><th>Total</th></tr><tr><td>Students</td><td>66</td><td>8</td><td>20</td><td>94</td></tr><tr><td>Teachers</td><td>12</td><td>29</td><td>15</td><td>56</td></tr><tr><td>Total</td><td>78</td><td>37</td><td>35</td><td>150</td></tr></table>	**2**
	b	.1 Correct number of students who travel by bus or car .2 Correctly divide their86 by their total number of students in part (a)	.1 86 .2 $(\frac{their86}{their150})$ or $\frac{43}{75}$ or 0.57(333...) OE	**2**
	c	$\frac{15}{56}$ or 0.267(857...) OE		**1**
	d	.1 Correct initial probability .2 Multiply three probabilities without OR with replacement .3 Correctly multiply their three probabilities without replacement .4 Correctly multiply their product of probabilities by 3	.1 $\frac{12}{56}$ OE or $\frac{44}{56}$ OE ACCEPT seeing it embedded in calculations .2 their$(\frac{12}{56}\times\frac{11}{55}\times\frac{44}{54})$ OR their$(\frac{12}{56}\times\frac{12}{56}\times\frac{44}{56})$or $\frac{99}{2744}$ or 0.036(07..) .3 their$(\frac{5808}{166320})$ or their$(\frac{11}{315})$ or their 0.0349(2…) OE ACCEPT 0.035 .4 their$(\frac{17424}{166320})$ or their$(\frac{33}{315})$ or their 0.1047(61..) ACCEPT 0.105 Accept only if $0 \leq$ probability ≤ 1	**4**

Q2		Answers	Notes	Total
	a	.1 Correctly state 1st transformation .2 Correctly state 2nd transformation	.1 vertical stretch or dilation by a factor of 4 ACCEPT enlargement .2 vertical translation of –1 or shift down 1 unit WTTE	**2**
	b	**AM1** .1 Correctly rearrange the equation to have $(x – 5)^2$ on one side .2 Correctly square root .3 Correctly calculate their two values of x **AM2** .1 Correctly expand the equation to have all terms on one side equal zero .2 Correctly factorise their quadratic or correctly substitute their coefficients into quadratic formula .3 Correctly calculate their two values of x	**AM1** .1 $(x-5)^2 = \frac{1}{4}$ OE .2 $x-5 = \pm\frac{1}{2}$ OE ACCEPT $x-5 = \frac{1}{2}$ .3 x = their4.5 AND x = their5.5 OE **AM2** .1 $4x^2 - 40x + 99 = 0$ ACCEPT $4x^2 - 40x + 100 - 1 = 0$ .2 $(2x-9)(2x-11)$ or $\frac{40 \pm \sqrt{40^2 - 4 \times 4 \times 99}}{2 \times 4}$ OE ACCEPT solving correctly their simpler quadratic for one value of x .3 x = their4.5 AND x = their5.5 OE ACCEPT their correctly calculated values provided only one mistake in substitution into the quadratic formula	**3**

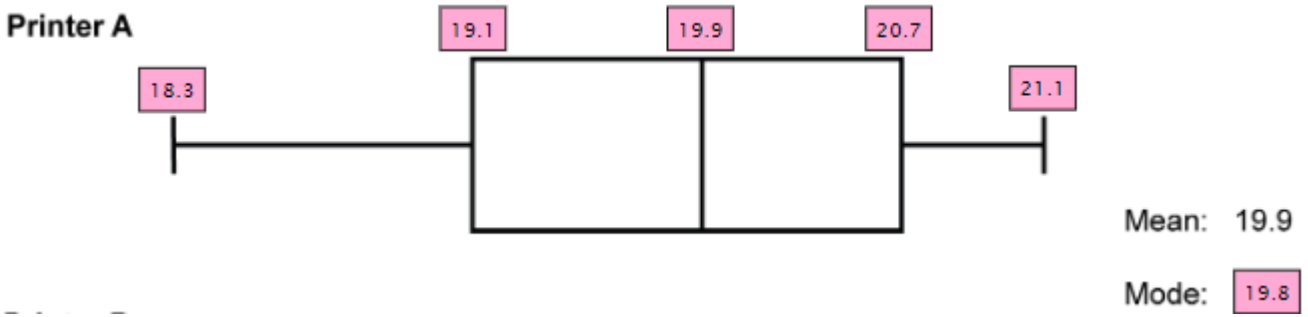
	c	.1 Correctly place two items .2 Correctly place the rest of the five items	 DO NOT ACCEPT if their 4.5 and their 5 are switched in places DO NOT ACCEPT their inequalities in the boxes e.g. x> 4.5	**2**

Q3		Answers	Notes	Total
	a	.1 Correct use of Pythagoras .2 Correct value of height .3 Correct comparison of their 230.48... and 230 Storage unit cannot be lifted into place AG	.1 $50^2 + 225^2 = h^2$ *OE* .2 (*h* =) 230.48(…) ACCEPT 230.5 .3 their230.48(…) > 230 or anything that WTTE Ex: 230.48 is greater than height of ceiling .3 ACCEPT 53125 > 52900 or anything that WTTE .3 DO NOT ACCEPT unless .1 or .2 is awarded	**3**
	b	.1 Correctly substitute *h*, *x* and 230 into the Pythagoras's theorem .2 Correctly rearrange the formula to have *h* on one side	.1 $h^2 + x^2 = 230^2$ OE .1 ACCEPT using inequality sign .2 (*h* =) $\sqrt{52900 - x^2}$ OE .2 ACCEPT using inequality sign	**2**
	c	Correctly calculate their *h* using *x*=50 and 230 into their formula for *h*	Their 224(.4994432) ACCEPT in the working ex: $50^2 + 224.(499)^2 = hyp^2$ DO NOT ACCEPT 224.49	**1**
	d	.1 Correctly substitute 50 and 220 into volume of cuboid .2 Correct calculate their volume for their height	.1 50 x 50 x 220 .2 their550 000 (cm^3)	**2**

Q4		Answers	Notes	Total
	a	.1 A correct reason for a pair of congruent angles .2 A correct reason for another pair of congruent angles (AA) $\triangle ABC \sim \triangle ADE$ AG	**Examples of correct reasons for pair of congruent angles:** - Angle BAC = Angle DAE or Angle A is common angle or same angle A WTTE. (They have to mention the angle A). ACCEPT angle A = angle A DO NOT ACCEPT they share same angle or they have a common angle - Angle ABC= Angle ADE with reason Ex: BC parallel to DE or parallel lines or corresponding angles ACCEPT Angle B = Angle D instead of Angle ABC= Angle ADE - Angle ACB= Angle AED with reason Ex: BC parallel to DE or parallel lines or corresponding angles ACCEPT Angle C = Angle E instead of Angle ACB= Angle AED DO NOT ACCEPT Angle ABC and Angle ADE are similar or Angle ACB and AED are similar DO NOT ACCEPT seeing only Angle ABC= Angle ADE or Angle ACB= Angle AED without correct reasoning	**2**

	b	**AM1** .1 Correct ratio .2 Their correct ratio of area (squaring their ratio) .3 Multiply their ratio of area by 9 .4 Correctly subtract their area of triangle ADE by 9 **AM2** .1 Correct ratio .2 Correctly calculate length BC .3 Correctly calculate their length of DE .4 Correctly calculate their area of trapezium	**AM1** .1 $\frac{7}{3}$ or 0.428(57…) OE ACCEPT $\frac{3}{7}$ OE .2 $(\text{their}\frac{7}{3})^2$ OE .3 $\text{their}(\frac{7}{3})^2 \times 9$ or 49 .3 ACCEPT seeing their $\frac{7}{3} \times 9$ or 21 BUT DO NOT ACCEPT *their* $\frac{3}{7} \times 9$ .4 (their49-9=) their 40 (cm^2) Accept only if positive **AM2** .1 $\frac{7}{3}$ or 0.428(57…) OE ACCEPT $\frac{3}{7}$ OE .2 $(9 = \frac{1}{2} \times BC \times 3 \times \sin 96), (\text{BC} =) 6.03(3...)$ OR $(\frac{3 \times \sin 59}{\sin 96} =) 6.084(69...)$ .3 $(\textit{their}\frac{7}{3} \times \textit{their} 6.03(...) =) 14.077(1...)$ ACCEPT 14 .4 $(\frac{1}{2} \times \textit{their} 14.077(1...) \times 7 \times \sin 96 - 9) = \textit{their} 39.99$ ACCEPT 39.98 OR $(\frac{6.03(3...) + \textit{their} 14.077(1...)}{2} \times (\frac{9}{0.5 \times 6.03(3...)} \times \frac{7}{3} - \frac{9}{0.5 \times 6.03(3...)}) = 40(.03...)$ .4 ACCEPT their 40 only if .2 and .3 are awarded	**4**

	c	**AM1** .1 Correct substitution into sine rule .2 Correctly rearranging to make $\sin\angle ABC$ the subject .3 Correctly calculate the angle ABC using their sine rule **AM2** .1 Correctly calculate length BC .2 Correctly substitute their sides of triangle ABC into cosine rule .3 Correctly calculate the angle ABC using their cosine rule 25 AG	**AM1** .1 $\frac{\sin\angle \text{ABC}}{3}=\frac{\sin 96}{7}$ OE .2 $((\sin\angle ABC)=)\ \frac{3\sin 96}{7}$ .3 25.2(…) **AM2** .1 $(9=\frac{1}{2}\times BC\times 3\times\sin 96)$, (BC =)6.03(3...) OR $(\frac{3\times\sin 59}{\sin 96}=)6.084(69...)$ .2 $(\cos B=)\frac{their\,6.03(3...)^2+7^2-3^2}{2\times their\,6.03(3...)\times 7}$ OE .3 25.2(…) ACCEPT their25.2 if it rounds to 25	**3**
	d	**AM1** .1 Correctly calculate angle BAC .2 Correctly substitute their angle BAC into cosine rule .3 Correctly calculate their BE after substitution into cosine rule **AM2** .1 Correctly calculate angle BAC .2 Correctly calculate angle ABE (or AEB) AND correctly substitute their values into sine rule .3 Correctly calculate their BE after substitution into sine rule **AM3** .1 Correctly calculate angle BAC .2 Correctly calculate angles of triangle BCE AND correctly substitute their values into sine rule or cosine rule .3 Correctly calculate their BE after substitution into sine rule	**AM1** .1 (180 – 96 – 25 =) 59 (degrees) ACCEPT their25 .2 $(BE^2)=7^2+7^2-2\times 7\times 7\times\cos(their\,59)$ or 47.5(2626…) .3 their 6.89(39…) (cm) ACCEPT 7 only if .2 or .1 is awarded **AM2** .1 (180 – 96 – 25 =) 59 (degrees) .2 (ABE or AEB)= $(\frac{180-59}{2}=)60.5$ AND $\frac{7}{\sin 60.5}=\frac{BE}{\sin 59}$ .3 their 6.89(39…) (cm) ACCEPT 7 only if .2 or .1 is awarded **AM3** .1 (180 – 96 – 25 =) 59 (degrees) .2 (BCE=)84 and $(\text{CBE}=\frac{180-59}{2}-25)=35.5$ AND $\frac{4}{\sin 35.5}=\frac{BE}{\sin 84}$ or $6.(033...)^2+4^2-2\times 4\times 6.(033...)\times\cos 84$ .3 their 6.85(04…) (cm) ACCEPT 7 only if .2 or .1 is awarded	**3**

Q5	Answers	Notes	Total
a	Correct mass of phone case	(1.25 x 29 =) 36(.25) (g)	**1**
b	.1 Divide 1000 by their mass .2 Correctly rounds their answer to nearest whole number	.1 $\frac{1000}{their\,36.25}$ or 27.586.. .2 their27 ACCEPT only if $\frac{1000}{their\,36.25}$ is not a whole number	**2**
c	.1 Correct method to calculate the mean .2 Correct value of mean before rounding 19.9 AG	.1 $\frac{18.3 + 18.5 + 19.1 + \ldots + 21.1}{11}$ or $\frac{218.7}{11}$ ACCEPT 18.3 + 18.5 + 19.1 +…+ 21.1 /11 .1 ACCEPT if they divide at least sum of eight values by 10 or 11 .2 19.88(18….) DO NOT ACCEPT 19.89	**2**
d	.1 two correct values .2 another two correct values .3 another two correct values	 Min 18.3, Q1 19.1, Median 19.9, Q3 20.7, Max 21.1 and Mode 19.8	**3**

	e	One fully correct reason for Printer A referring to a measure of dispersion or mode Printer A is better AG .	Examples (WTTE): has smaller IQR has smaller range less spread Mode is less ACCEPT most recurring time or most common or most frequent ACCEPT Printer A is better because it is more reliable or more consistent ACCEPT using the descriptor 'better' for 'less/lower/smaller' WTTE DO NOT ACCEPT comments about skewness ex: less skewed DO NOT ACCEPT the length of the box is smaller DO NOT ACCEPT comments just about the maximum Ex: The maximum is less	**1**
	f	One fully correct reason for Printer B referring to a measure of central tendency Printer B is better AG	Examples (WTTE): has a lower median has smaller average ACCEPT using the descriptor 'better' for 'less/lower/smaller' WTTE ACCEPT "smaller Q1 and Q3" DO NOT ACCEPT smaller Q1 only or smaller Q3 only DO NOT ACCEPT comments just about the minimum Ex: The minimum is less	**1**

Q6		Answers	Notes	Total
	a	.1 b = 2.5 OE ACCEPT [2,2.5] OE .2 c = 50 OE	ACCEPT using capital letters ACCEPT seeing values replaced in the equation	**2**
	b	.1 (*n* =)8 and (*Fmax*) = 96 (%)		**1**
	c	**AM1 (Solving)** .1 Equate their E with $-1.5(n-8)^2+96$ .2 Correctly expand $(n-8)^2$ and multiply by -1.5 .3 Correctly rearrange their quadratic equation on one side = 0 .4 Correctly substitute into quadratic formula .5 Correctly calculate their *n* **AM2 (substitution trials)** .1 Correctly substitute in their E and the F same value of n, accept decimal **within domain** .2 Correctly calculate their value of E and the value of F for their value of n .3 Correctly calculate their value of E and the value of F for another value of n .4 Compare value of E and F .5 Correctly identify their *n* **within the given domain**	**AM1 (Solving)** .1 *their* $2.5n+50=-1.5(n-8)^2+96$ ACCEPT using < instead of = .1 ACCEPT their E to be 70 .2 $-1.5n^2+24n-96$ OE SEEN .3 their $1.5n^2-21.5n+50=0$ ACCEPT using < instead of = .4 their $\frac{21.5\pm\sqrt{21.5^2-4\times1.5\times50}}{2\times1.5}$ .5 (n=) Their 2.92 or 3 .5 ACCEPT their positive value of *n* correctly rounded regardless the domain **AM2 (substitution trials)** .1 Ex: $2.5(2)+50$ and $-1.5(2-8)^2+96$ .2 Ex: their55 and 42 when n=2 ACCEPT values from graph not exact .3 Ex: their60 and 72 when n=4 ACCEPT values from graph not exact .4 evidence of comparing values of their E and F at same value of n Ex: 72>their60 ACCEPT argument based on the graph .5 (n=) Their 3 . 5 DO NOT ACCEPT if n>8 .5 DO NOT ACCEPT their3 if they use only values from graph	**5**

	d	1 Correct value of h .2 Correct value of k .3 Substitute point (2,50) into conic form .4 Correct value of a	.1 h=8 ACCEPT seeing 8 in the expression $(L=)a(n-8)^2+k$ .2 k=86 ACCEPT seeing 86 in the expression $(L=)a(n-h)^2+86$ .3 $50=a(2-h)^2+k$ ACCEPT substituting n=2 and any values for a,f, and k that gives Ex: 4(2-5)^2+14=50 .4 $a=-1$ ACCEPT seeing –1 in the expression $(L=)-(n-h)^2+k$. 4 evidence of comparing values of their E and F at same value of n Ex: 72>their60 ACCEPT argument based on the graph .5 (n=)their3 .5 DO NOT ACCEPT if n>8 .5 DO NOT ACCEPT their3 if they use only values from graph	**4**

6	e					10
Mark		**1**	**2**	**3**	**4**	**5**
Identify factors (F)		State one factor from: - Number of observations - The y-intercept Ignore additional irrelevant factors				
Calculation (C)		Equate their L with $-1.5(n-8)^2+96$ OR Correctly substitute in their L and the F same value of n	Correctly Expand both quadratics Ex: $-n^2+16n-64+86=-1.5n^2+24n$ OR Correctly calculate their value of L and the value of F for a certain value of n	Correctly rearrange their quadratics on one side = 0 Ex: $0.5n^2-8n+22=0$ OR Correctly calculate their value of L and the value of F for another value of n	Correctly substitute into quadratic formula OR Compare value of L and F	Correctly calculate their value of n Ex: (n =)3.53 OR Correctly identify their n within the given domain Accept their correctly calculated n only if between 2 and 5
Accuracy (A)		Recognizing it is not accurate with weak justification Examples: (WTTE) these are approximate calculations and not accurate Inaccurate because of rounding Inaccurate because equations not accurate **OR** Sensible rounding used in calculations without a comment ex: 2.55 is 3 DO NOT ACCEPT: my results are accurate WTTE	Recognizing it is not accurate with acceptable justification Examples: The equations we are using are not exactly the models that represent the data OR Accurate with strong justification Ex: Regardless of the equation I use the intersection between both will still be in the range 2 to 3	—		———

Justify (J)	Weak Justification Appropriate comment on one of the methods Examples: (WTTE) - Correct comment on the graphical behaviour of a method -The success rate of E is 50% even with zero observations OR Attempt to comment on two or more methods Examples: (WTTE) - The Fisherface is most accurate (or highest success rate) - The maximum success rate for F is 96% while for L only 86%	Good Justification Appropriate comment/comparison on at least two methods Examples: (WTTE) - Fisherface is better than LBPH in the long run - When n = 2 or less use LBPH and when n = 4 or more use Fisherface - The maximum success rate for F is 96% while for L only 86% for the maximum n -The success rate of E is 50% even with zero observations while for others it is less ACCEPT: The Fisherface is most accurate (or highest success rate) for the maximum n. DO NOT ACCEPT if they do not have a choice of method			

Q7		Answers	Notes	Total
	a	**AM1** .1 correctly substitute 4 or -4 into the correct equation .2 subtract 2 from 16 **AM2** .1 equate 14 to g(x)-2 or f(x)-2 .2 evidence of determining x=4 using g(x) or x=-4 using f(x) 14 AG	**AM1** .1 $y = 2^4$ or (1/2)^ –4 .2 (height =) 16 – 2 or 2^4 – 2 **AM2** .1 $2^x - 2 = 14$ or $(\frac{1}{2})^x - 2 = 14$ .2 x=4 or x=-4 ACCEPT $2^4 = 16$ or $(\frac{1}{2})^{-4} = 16$	**2**

<table>
<tr>
<td></td>
<td>b</td>
<td>Correctly place 64 AND 128</td>
<td>
<table>
<tr><th>Stage (n)</th><th>Number
of new squares added
(S)</th></tr>
<tr><td>1</td><td>4</td></tr>
<tr><td>2</td><td>8</td></tr>
<tr><td>3</td><td>16</td></tr>
<tr><td>4</td><td>32</td></tr>
<tr><td>5</td><td>64</td></tr>
<tr><td>6</td><td>128</td></tr>
</table>
</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>.1 correctly describe one pattern for S in words

.2 correctly describe a second pattern for S in words</td>
<td>Examples of accepted terminology:
- Even numbers, multiples of 2
- Multiples of 8 except the first row OE
- Multiples of 4, divisible by 4
- Multiplies by 2, doubles, ratio 2, powers of 2, twice of previous, added to itself
-powers of 2
- Geometric with ratio 2

DO NOT ACCEPT incomplete terminology, for example:
Geometric, multiplies by a constant, has a common ratio, the even numbers or the multiples of 4

DO NOT ACCEPT the rule in words, for example:
2 power n+1

DO NOT ACCEPT
n goes up by 1
It is increasing
general rules in terms of n, example: S = 2^{n+1}

More than two different patterns, all correct award (2 marks)
Ex: multiplies by 2, and multiples of 4 and it is 2 to the power n+1
More than two different patterns, with any incorrect award (1 mark)
Ex: multiplies by 2, and multiples of 4 and it is 2 to the power n</td>
<td>2</td>
</tr>
</table>

	d	.1 the correct general rule .2 the correct simplified general rule with correct notation for S in terms of *n*.	.1 (S =) 2^{n+1} or $S = 2 \times 2^n$ ACCEPT $S = 4 \times 2^{n-1}$ OE .2 S = 2^{n+1} DO NOT ACCEPT description in words	**2**
	e	.1 correctly substitute $n \geq 5$ into their general rule . ·1 Correctly substitute n ≥ 5 into their general rule ·2 Correctly calculate their value of S after substituting n ≥ 5 ·3 Recognize that their result is the same as the correctly predicted value	.1 Ex: 2^{5+1} .2 Ex: 64 (for *n* = 5) .3 "the same as when we continue the pattern" WTTE and states how Ex: For n=5, 64 is obtained from pattern of multiplying 32 by 2 ·3 ACCEPT if their value from .2 is the same as their value in the table in part b) or seen here in part e)	**3**

7	f		22

Mark	1	2	3	4	5
Predictions (P)	Correctly predict one term for T ACCEPT whether in the table or in the response box	Correctly predict two terms for T ACCEPT whether in the table or in the response box			
Description (D)	Correctly describe a pattern in words or recursive rule for *T* (Ignore additional incorrect patterns) Ex : even numbers, multiples of 2 Multiples of 4 Increases by even numbers Increases by 8, 16, 32.. Adds up by 8, 16, 32... First difference doubles Difference is geometric Difference is 2^{n+1} Increases by 2S T=2S-4 or 2 power n Or Recursive rule: $T_n = T_{n-1} + S_n$ or $T_n = T_{n-1} + 4 \times 2^{n-1}$ or $T_n = 2T_{n-1} + 4$ OE DO NOT ACCEPT recursive rule in words or double S subtract 4	Correctly describe two patterns in words or recursive rule for *T* (Ignore additional incorrect patterns) **OR** Valid attempt to write general rule for T Ex: number times 2^n or number plus 2^n provided it is not the same S rule	Correctly describe one pattern in words or recursive rule for *T* (Ignore additional incorrect patterns) AND Valid attempt to write general rule for T **OR** Correctly describe the pattern for T as a general rule T = $2^{n+2} – 4$ OE	Correctly describe one patterns in words or recursive rule for *T* (Ignore additional incorrect patterns) AND Correctly write down the general rule for *T* **OR** Correctly describe two patterns in words or recursive rule for *T* (Ignore additional incorrect patterns) AND Valid attempt to write general rule for T	Correctly describe two patterns in words or recursive rule for *T* (Ignore additional incorrect patterns) **AND** Correctly write down the general rule for *T* ACCEPT the general rule in words but penalise in notation (for Notation see N)

Testing (T)	Attempt to test their general rule for T using $n \leq 4$ Correctly substitute in their general rule for T value of $n \leq 4$ **OR** Correctly test their rule for T or described pattern or recursive rule	Correctly test their general rule for T using $n \leq 4$ Correctly calculate their value for T in their general rule using $n \leq 4$ **AND** Recognize that their correctly calculated value for T is the same as the given value. ACCEPT testing correctly $T_n = T_{n-1} + 4 \times 2^{n-1}$ ACCEPT seeing their correctly calculated value for T and the given value in the table being equal			
Verifying (V)	Attempt to verify their general rule for T using $n \geq 5$ Correctly substitute in their general rule for T value of $n \geq 5$ **OR** Correctly verify their rule for T or described pattern or recursive rule	Correctly calculate their value for T in their general rule using $n \geq 5$	Correctly calculate their value for T in their general rule using $n \geq 5$ **AND** Recognise that their correctly calculated value for T is the same as their predicted value obtained by continuing the pattern ACCEPT verifying correctly $T_n = T_{n-1} + 4 \times 2^{n-1}$ ACCEPT seeing their correctly calculated value for T and their predicted value in the table being equal		

Justify/ proof (J)	Attempt to justify their described pattern or their general rule Ex: trying at least two more values and arguing as justification that they are the same or rule works or **seen as justification** Ex: It is partially geometric, the increase doubles so rule includes exponential WTTE Ex: The difference is geometric Weak attempt to justify their general rule geometrically Ex: T=2S-4 (or in words)	Justify their general rule arithmetically Ex: **Seen as justification** Part of it is geometric with first term 4 and ratio 2 then we subtract 4 **OR** Attempt to justify their general rule geometrically Ex: Try to calculate area rectangle Adding $2^{n+1}+2^{n+2}+...$ T=2S-4 (or in words) and $2^{n+2}-4=2\times 2^{n+1}-4$	Good attempt to justify the general rule for T geometrically by using incorrect equations or information. height of $y = 2^x$ minus the blank space under the rectangle of area 4 (4 squares) and x=n+2 **OR** Good attempt to proof by induction	Correctly justify the general rule for T geometrically by using area of rectangle with base 2 and functions for the height. Total number of squares is the area of a rectangle with base 2 and height of $y = 2^x$ minus the blank space under the rectangle of area 4 (4 squares) $x = n + 1$ (because of starting at x=2) A = b*h – 4 $A = 2*(2)^{n+1} - 4$ $A= 2^{n+2} - 4$ **OR** Correctly proof by induction J4 automatically gains T2 and V3	

Communication criteria

Mark	1	2	3
Notation and terminology (N)	Correct notation of their general rule for T **OR** The notation of the general rule for T includes errors, ex: 2^(n+2)-4 or non-simplified general rule Ex: $T = 2(2^n + 2^n) - 4$ **OR** Correctly describe at least one pattern in words for T DO NOT ACCEPT if they don't have any rules and they don't describe any patterns	Correct notation of the general rule for T $T = 2^{n+2} - 4$ ACCEPT $T = 4 \times 2^n - 4$ or $T = 4(2^n - 1)$ ACCEPT the use of brackets **OR** The notation of the general rule includes errors (see examples in N1) **AND** Correctly describe at least one pattern in words for T ACCEPT using U_n instead of T only if they mention that $T = U_n$ DO NOT ACCEPT using * for multiplication using / for division using ^ for power Using x instead of n DO NOT ACCEPT if they don't have the general rule for T	Correct notation of the general rule for T (see examples in N2) **AND** Correctly describe at least one pattern in words for T ACCEPT using U_n instead of T only if they mention that $T = U_n$ DO NOT ACCEPT using * for multiplication using / for division using ^ for power Using x instead of n DO NOT ACCEPT if they don't have the general rule for T

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Mark	1	2	3
Communication (L) Organisation and coherence Can be awarded even if there are errors Describing pattern and writing rule can be considered an item even if D0 awarded Test, verify, and justify may include errors but cannot be considered item (or identified for coherence) if they are zeros	**At least three** from the following items are seen: · describe a pattern in words · write a rule · test their general rule or rule or recursive rule or pattern (at least T1) · verify their general rule or rule or recursive rule or pattern (at least V1) · justify their general rule or rule or recursive rule or pattern (at least J1)	DO NOT ACCEPT if they don't have a general rule **At least four** of the following items are seen: · describe a pattern in words · write a general rule · test their general rule (at least T1) · verify their general rule (at least V1) · justify their general rule (at least J1) **AND** For coherence, they identify the processes correctly. **At least one** from the following: · test (at least T1) · verify (at least V1) · justify (at least J1) Ex: • **For test:** they say "test" and they test using value(s) of $n \leq 4$ only • **For verify:** they say "verify" and they verify using value(s) of $n \geq 5$ only • **For test and for verify:** they say 'test **and** verify' and they test using value(s) of $n \leq 4$ **and** then verify using value(s) of $n \geq 5$ **For justify:** At least J1 awarded	**The following two items must be seen** : • write the general rule for T • justify the general rule (at least J2) **AND** **At least two** of the following items are seen: • describe a pattern or rule in words • test the general rule (at least T1) • verify the general rule (at least V1) **AND** For coherence, they identify the processes correctly. **At least one** from the following: • test (at least T1) • verify (at least V1) Ex: • **For test:** they say "test" and they test using value(s) of $n \leq 4$ only • **For verify:** they say "verify" and they verify using value(s) of $n \geq 5$ only • **For test and for verify:** they say 'test **and** verify' and they test using value(s) of $n \leq 4$ **and** then verify using value(s) of $n \geq 5$

Stage (n)	Number of new squares (S)	Total number of squares (T)
1	4	4
2	8	12
3	16	28
4	32	60
5	64	124
6	128	252
7	256	508
8	512	1020