MYP mathematics May 2022: A student resource illustrating advice from the subject report

Dear student,

The link given below is to a resource formatted in Microsoft Sway that illustrates advice from the May 2022 subject report for the MYP mathematics examination. The examples used in the resource are taken from student responses, however the general advice can be transferred to any examination. The resource was subject to a trial with a group of students and their feedback was implemented. Included in this resource are the May 2022 mathematics examination, the markscheme and the subject report.

Navigate to the resource here.

This resource contains unedited, authentic work of educators and as such may contain material which does not follow the spelling and grammar style of the IB.

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Instructions

The on-screen examination has not yet started.

Your time will begin once you have clicked the **Start** button below. Do not click **Start** until instructed to do so.

Before the examination begins you are given 5 minutes to become familiar with its structure. Please navigate around the examination, taking note of the length of each task and question. You have **2 hours** to complete the examination.

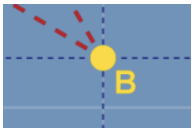
There are **8** separate questions in this examination. Each question may have sub-parts. Answer all the questions in the response boxes provided. The maximum mark for this examination is **98 marks**.

As you progress through the questions, your answers are automatically saved.

When 2 hours has ended, you will no longer be able to answer any questions.

START INVIGILATOR MENU Quit

Question 1 (7 marks)



Knowing and understanding

In this task (questions 1 to 5), you will interact with different aspects of **form** using a variety of related concepts. This task focuses on **criterion A** (Knowing and understanding) and **criterion C** (Communication).

Use a Venn diagram to find probabilities.

Question 2 (7 marks)

Use properties of triangles to find lengths.

Question 3 (9 marks)

Make statistical calculations from a cumulative frequency graph.

Question 4 (4 marks)

Use properties of parabola to determine the unknown values in equations.

Question 5 (10 marks)

Use bearings and properties of shapes to find angles and distances.

Question 6 (12 marks)



Applying mathematics in real-life contexts

In this task (questions 6 and 7), you will use **relationships** to apply mathematics within the global context of **personal and cultural expression**. This task focuses on **criterion D** (Applying mathematics in real-life contexts) and **criterion C** (Communication).

Find areas and lengths in cultural masks.

Question 7 (16 marks)

Explore relationships between tiered seating and the space available in a theatre.

Question 8 (33 marks)



Investigating patterns

In this task (question 8), you will use **logic** to investigate the formation of triangular patterns. You will be assessed using **criterion B** (Investigating patterns) and **criterion C** (Communication).

Describe patterns and find general rules for the perimeter of triangular formations.

Question 1 (7 marks)

Question 1a (1 mark)

The probability of two events, A and B, are illustrated in the Venn diagram below.

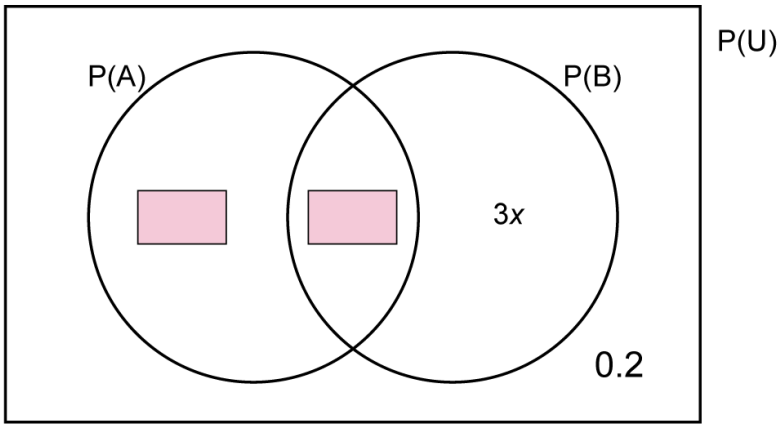
It is given that $P(A' \cap B) = 3x$, $P(A \cap B') = 4x$ and $P(A \cap B) = x$.

Select the missing probabilities to complete the Venn diagram.

Draggable items:

x

$4x$



Question 1b (1 mark)

Write down the value of $P(A \cup B)$.

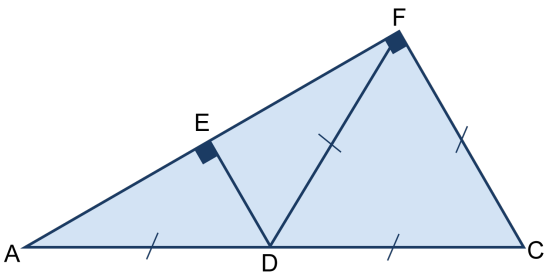
Question 1c (3 marks)

Find the value of $P(A \cap B)$.

Question 1d (2 marks)

Hence, **identify** if events A and B are mutually exclusive.

Question 2 (7 marks)



Given that AD = DC = DF = FC = 5 m:

Question 2a (2 marks)

Determine the length of AF.

Question 2b (2 marks)

Show that triangle AFC is similar to triangle AED.

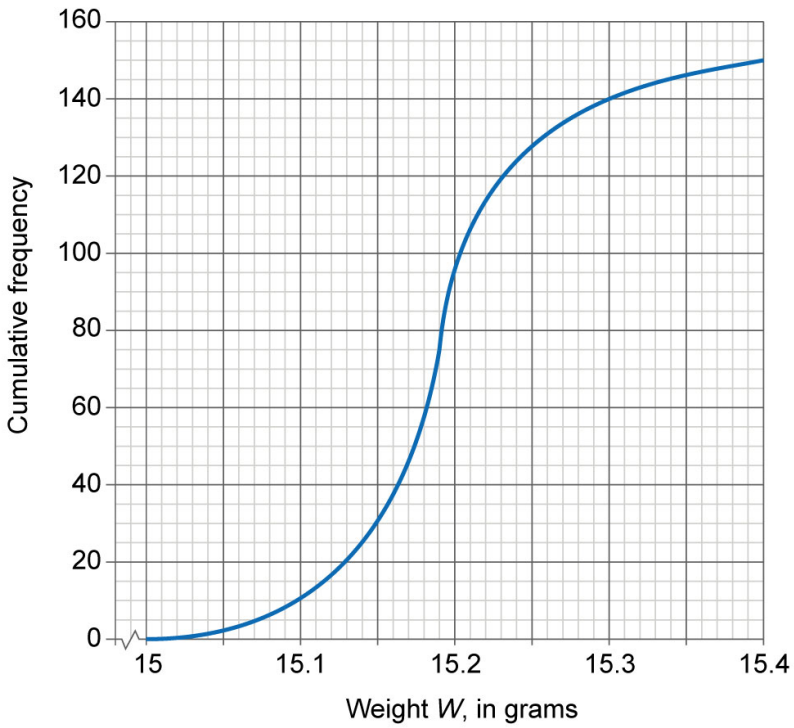
Question 2c (3 marks)

Hence, **find** the length of AE.

Question 3 (9 marks)

The following data is based on candy produced in a factory. A quality control manager samples 150 bars of candy and records the weight, W in grams, of each candy bar.

The data is shown in the cumulative frequency graph below.



Question 3a (2 marks)



There are 12 candy bars in a pack. Using the median weight of one bar of candy, **determine** the weight of a pack of candy.

The candy is categorized, by weight, into three different sizes.

Weight (grams)	Frequency
$15 \leq W < 15.1$	10
$15.1 \leq W < k$	120
$k \leq W < 15.4$	n

Question 3b (2 marks)

Determine the value of n.

Question 3c (2 marks)

Hence, **determine** the value of k.

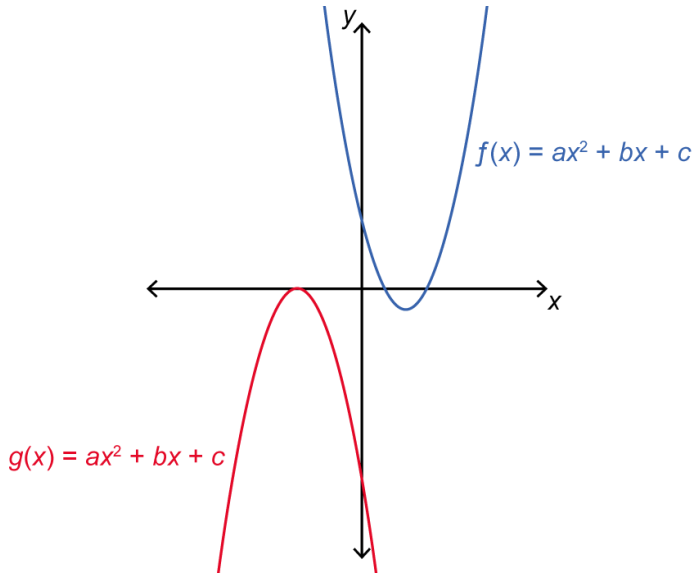
Question 3d (3 marks)

6 % of candies are rejected as the size is too large.

Find the minimum weight of the rejected candy.

Question 4 (4 marks)

The functions, $f(x)$ and $g(x)$, are shown in the graph below.



The values of a, b and c are different for $f(x)$ and $g(x)$.

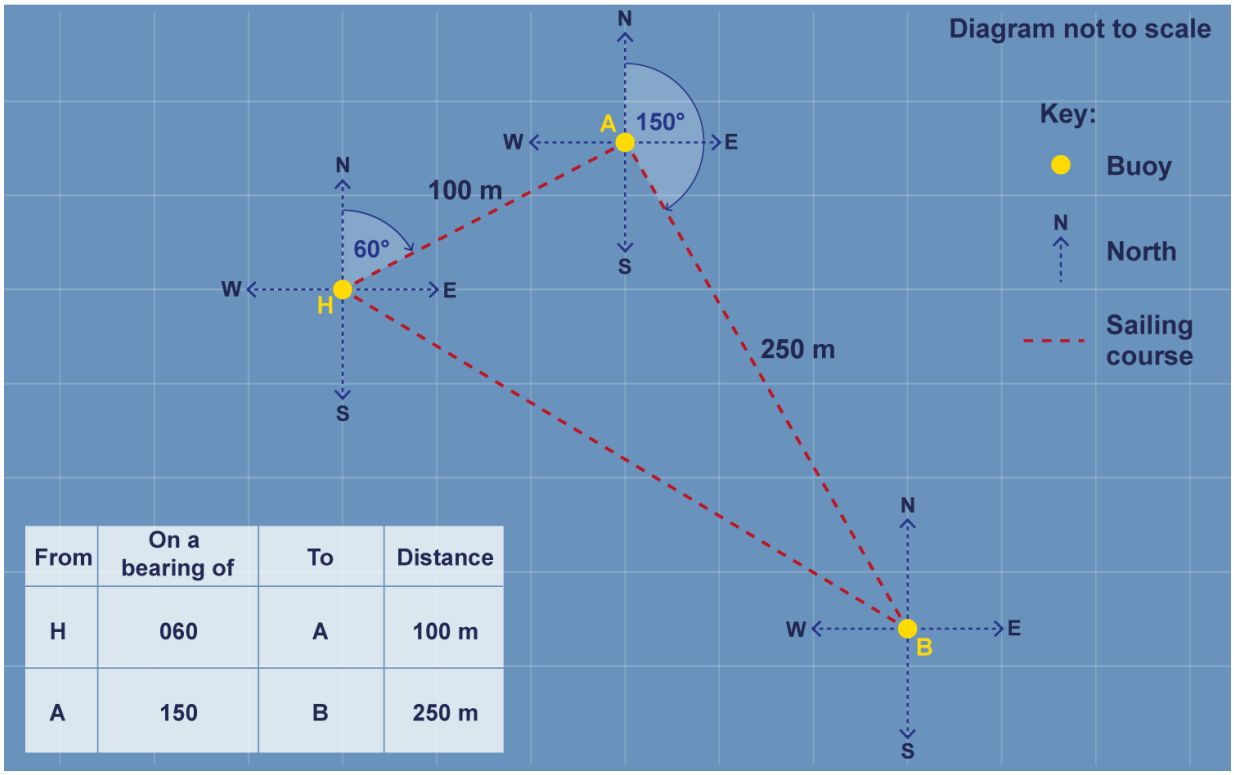
Select the correct options to complete the table. Use the draggable items provided.

Draggable items:		a	b	c
Zero Positive Negative	f(x)			
	g(x)			

Question 5 (10 marks)

Question 5a (2 marks)

The diagram below shows a sailing course for a yacht race. The route for the course is laid out with buoys that the yachts must pass. The details of the sailing course are provided in the table.



From	On a bearing of	To	Distance
H	060	A	100 m
A	150	B	250 m

Question 5a (2 marks)

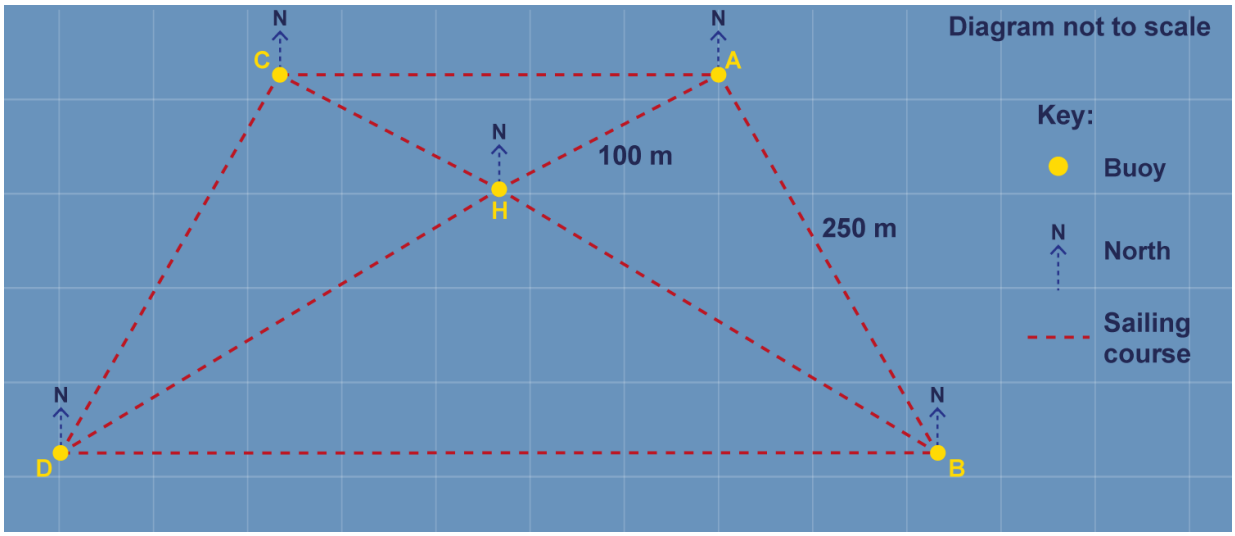
Show that the size of the angle HAB is 90 degrees.

Question 5b (3 marks)

Calculate the distance from B to H to the nearest metre.

Question 5c (5 marks)

The course for the yacht race is made longer by setting two more buoys at C and D. They are set as a reflection of buoys A and B respectively, on the vertical line passing buoy H.



The race will start from buoy H and the yachts must pass all the buoys exactly once and return to H.

The route for the race will be in the order H-B-A-C-D-H.

Find the total distance travelled.

Question 6 (12 marks)



"In Africa, masks serve an important role in rituals or ceremonies with varied purposes like ensuring a good harvest, addressing tribal needs in time of peace or war, or conveying spiritual presences in initiation rituals or burial ceremonies."

A designer is creating two masks, Mask A and Mask B. They are created using geometrical shapes and symmetrical properties. Interact with the stage control to see how Mask A is created.

Mask A

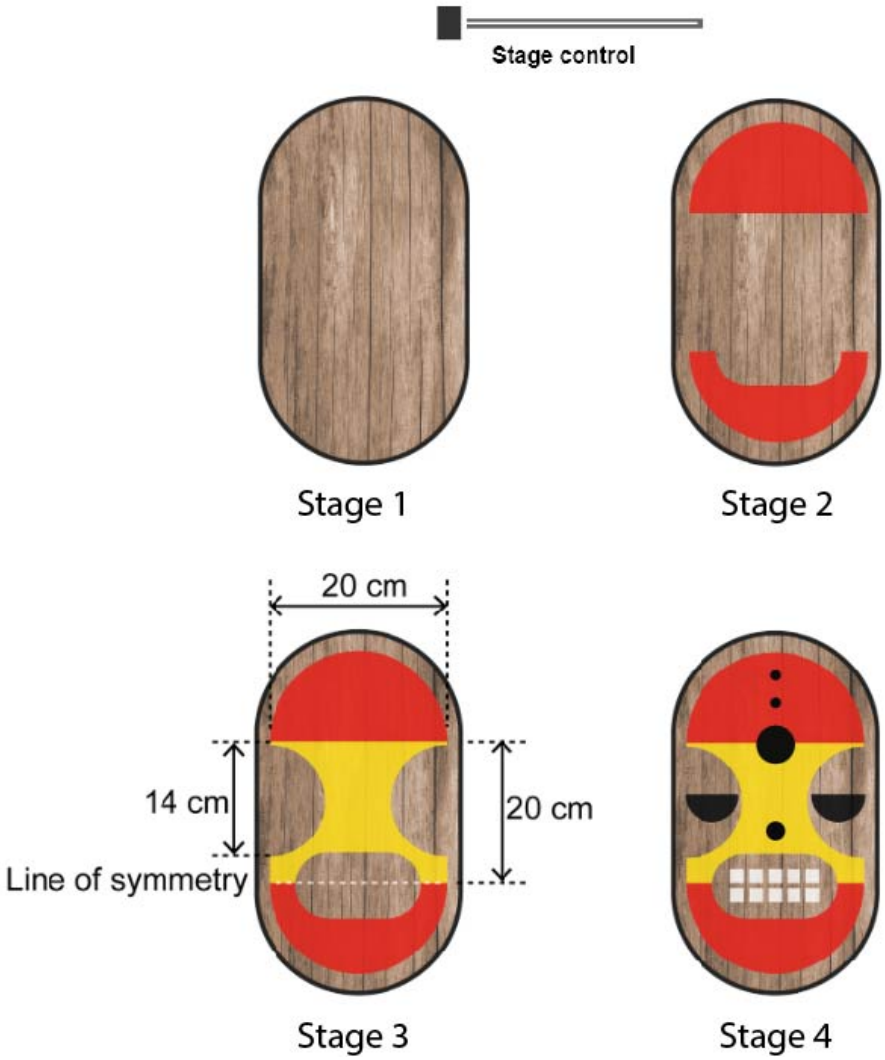
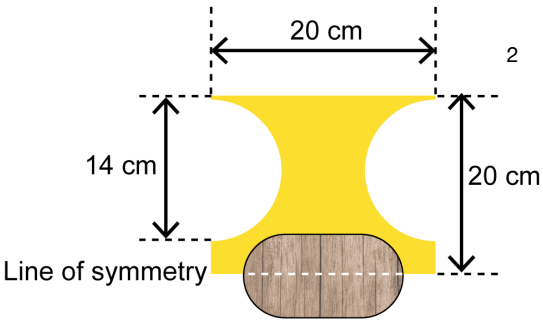


Diagram not to scale



Key:

Area of mouth 100 cm^2

Question 6a (4 marks)

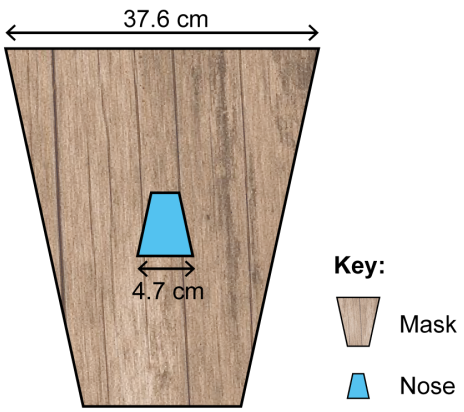
Show that the area in yellow is 196 cm^2 to the nearest whole number.

Question 6b (3 marks)

The wooden template for Mask B is shown below.

Mask B

Diagram not to scale



For artistic purposes, the designer wants the mask and nose to be in the shape of **similar** trapeziums.

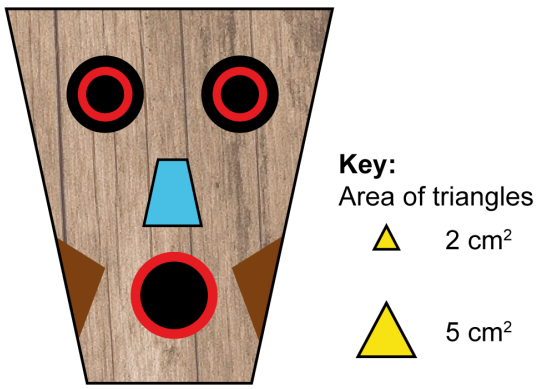
The area of the mask is 1184 cm^2. **Show that** the area of the nose is 18.5 cm^2.

Question 6c (5 marks)

The decoration of Mask B is not complete; the designer will now add triangles of two sizes using yellow paint.

Mask B is decorated with the following instructions:

- the yellow paint available can cover a total area of 80 cm^2
- use yellow paint to add triangles of two sizes
  - small triangle with area of 2 cm^2
  - big triangle with area of 5 cm^2
- the number of small triangles must be equal to 4 times the number of big triangles



Given that:

x : number of small triangles
y : number of big triangles
$x = 4y$

Given that there is only 80 cm^2 of yellow paint available, **find** the maximum number of small and big triangles that can be added to the mask.

Question 7 (16 marks)

Video | Script

Theatre performances are an important form of how society gathers to enjoy and appreciate creative expression. The first examples of theatre performances are thought to date back as far as the 6th century BCE.

Theatre seating is designed to ensure that audiences can enjoy performances from anywhere in the space. Tiered seating is proven to provide the best experience.

Many small theatres use mobile tiered seating that can be folded away when not in use. Here we have an example of a tiered seating design.

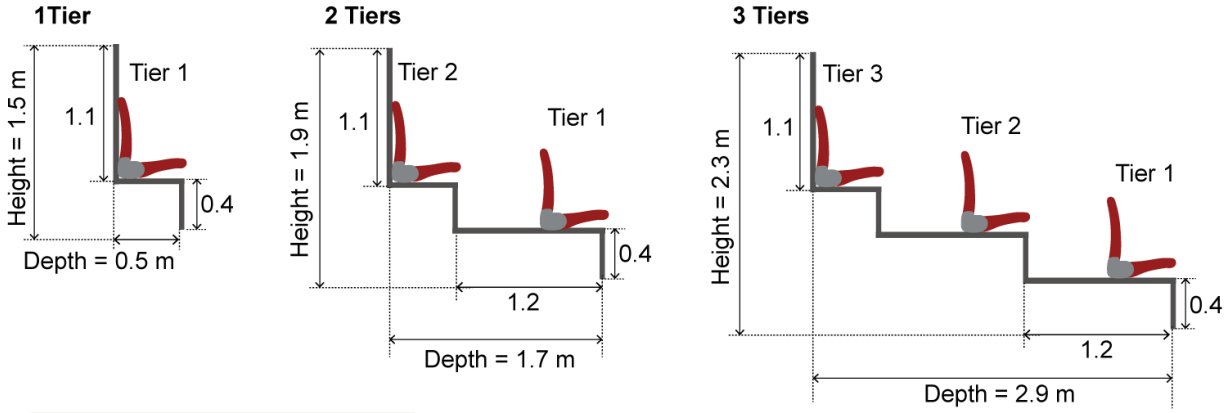
The manufacturers of the mobile seating systems must adhere to the following safety requirements when producing the seating:

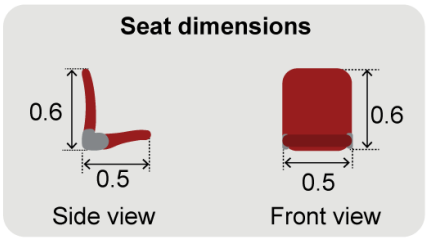
- there must be safety barriers on the side and back of the seating
- the tiered seating must not be above 6 metres high.
- six seats are connected to create sections of seats.
- there must be a gap of 1.5 metres between sections of seats.
- and there must be exit spaces of at least 2 metres on each side of the tiered seating.

In this question you will explore the possible designs for tiered seating for this theatre space.

Question 7 (16 marks)

Below is a cross-sectional view of tiered theatre seating.



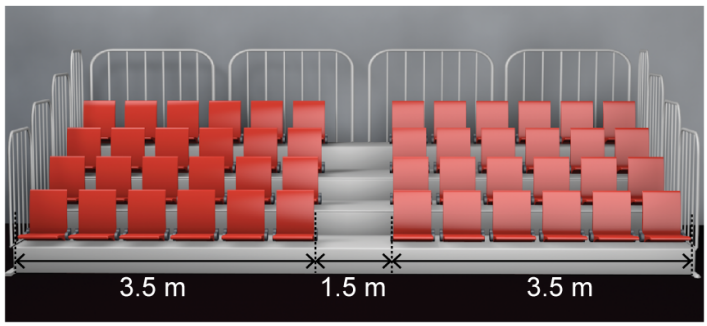


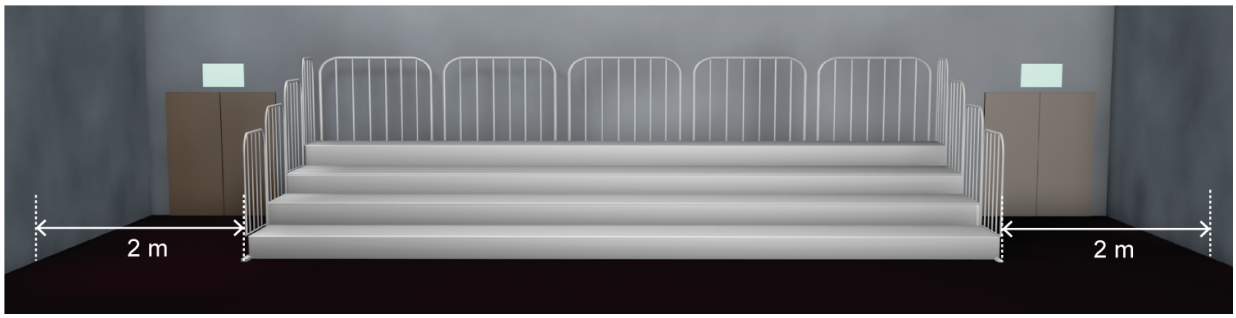
Question 7a (3 marks)

Calculate the maximum number of tiers for a height of 6 metres.

Question 7b (3 marks)

Each section of seating is 3.5 m wide. For access and safety a 1.5 m gap must be left between each section of seating and 2 m at the ends of each side.





Let x represent the maximum possible number of sections of seating per row that will fit in a theatre of width of 30 m.

Show that $x = 5$.

Question 7c (10 marks)

The maximum seating capacity for the theatre is 348.

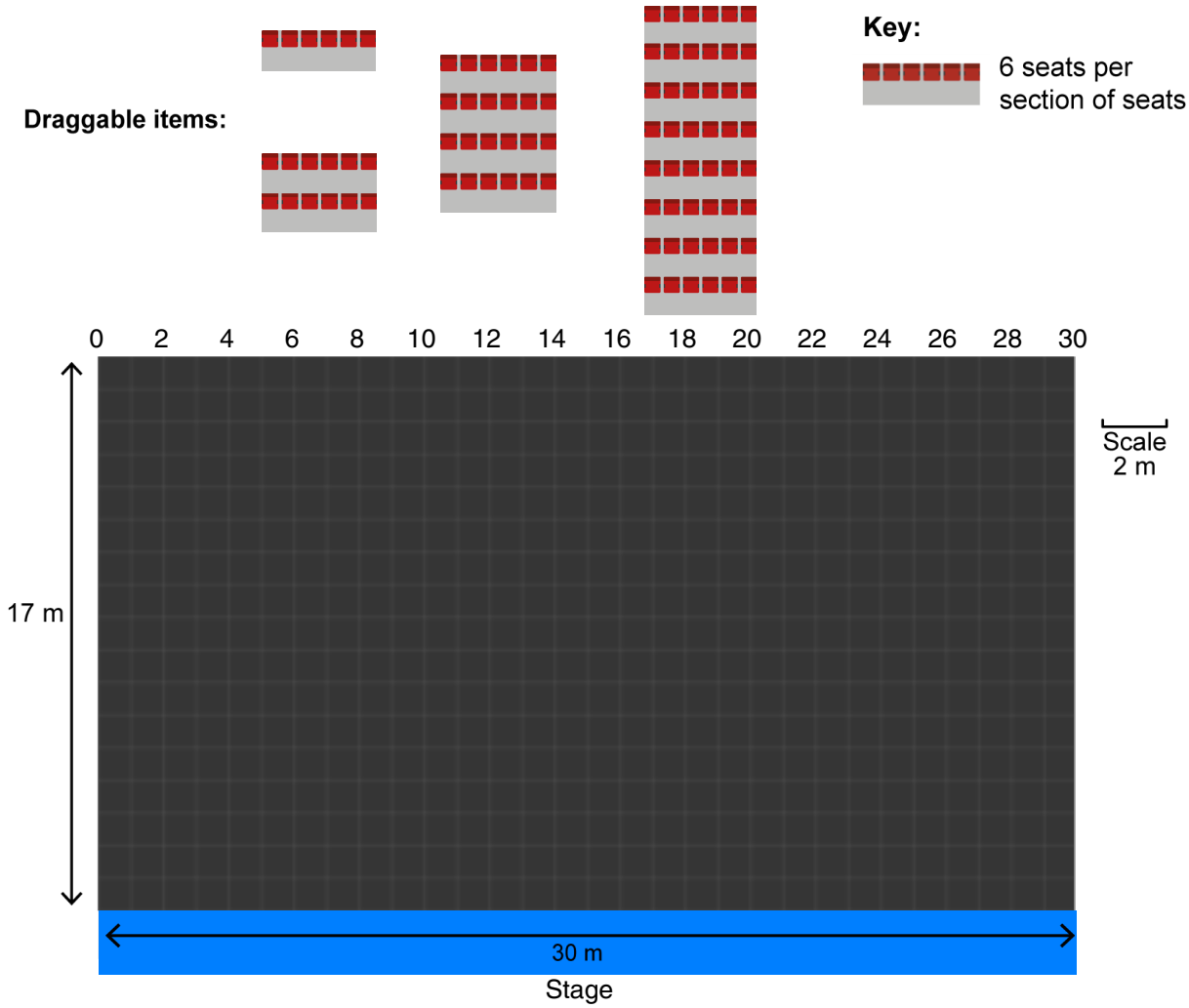
Using the constraints and your answers from previous parts, **design** tiered seating for the theatre for the maximum number of people.

In your answer you should:

- clearly identify **three** relevant factors
- make calculations for the number of seats per row
- make calculations for the number of seats for the whole tiered seating
- use the canvas to illustrate your design
- justify whether your design makes the best use of the theatre space.

Three relevant factors

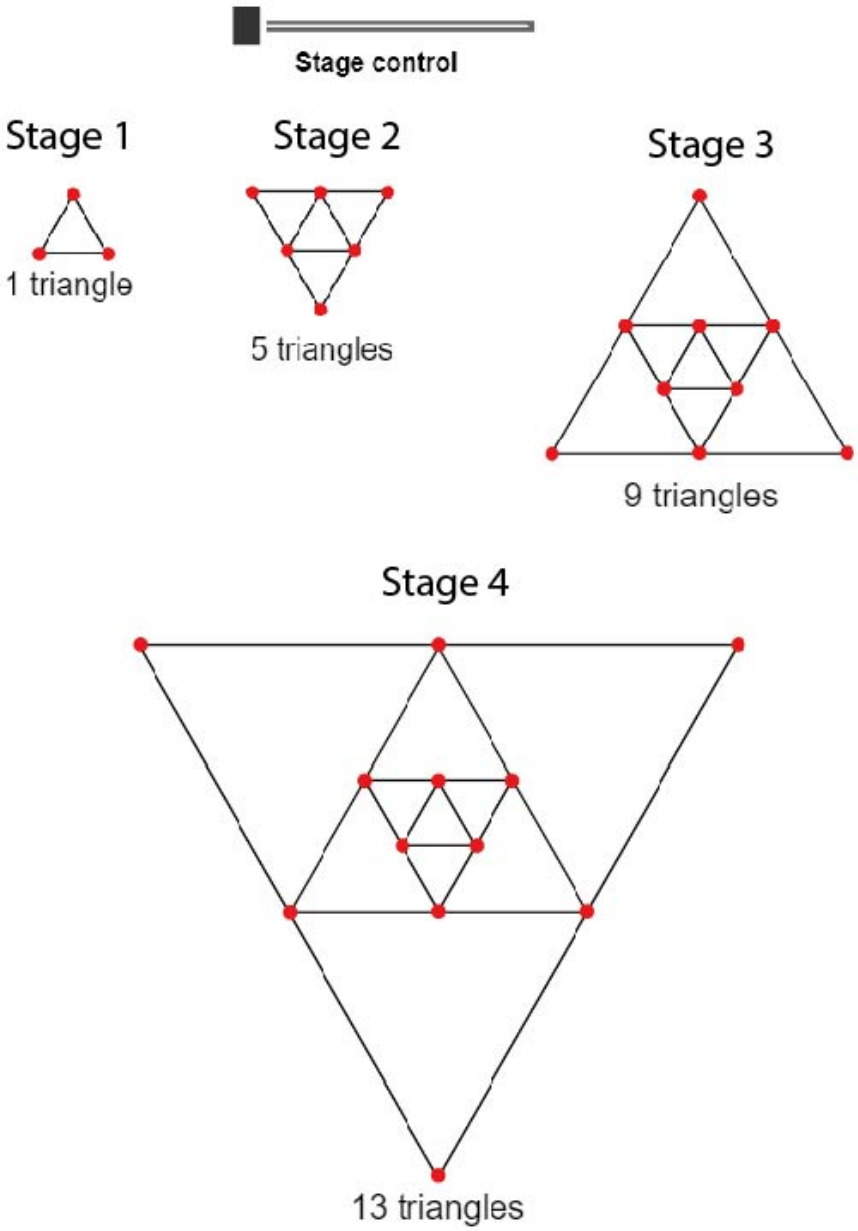
Calculations and justification


Draggable items:
Key:
6 seats per section of seats
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
17 m
Scale 2 m
30 m
Stage

Question 8 (33 marks)

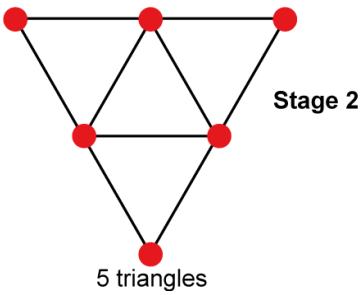
In this task you will investigate triangles.

Interact with the stage control to see how the equilateral triangles are formed.



Question 8a (1 mark)

Describe how stage 2 includes 5 triangles.



Question 8b (1 mark)

The table below shows number of triangles in each stage.

Write down the missing values in the table up to row 6.

Stage (n)	Number of triangles (T)
1	1
2	5
3	9
4	13
5	
6	

Question 8c (2 marks)

Describe in words two patterns in the table for the number of triangles (T).

Question 8d (2 marks)

Write down a general rule for T in terms of n.

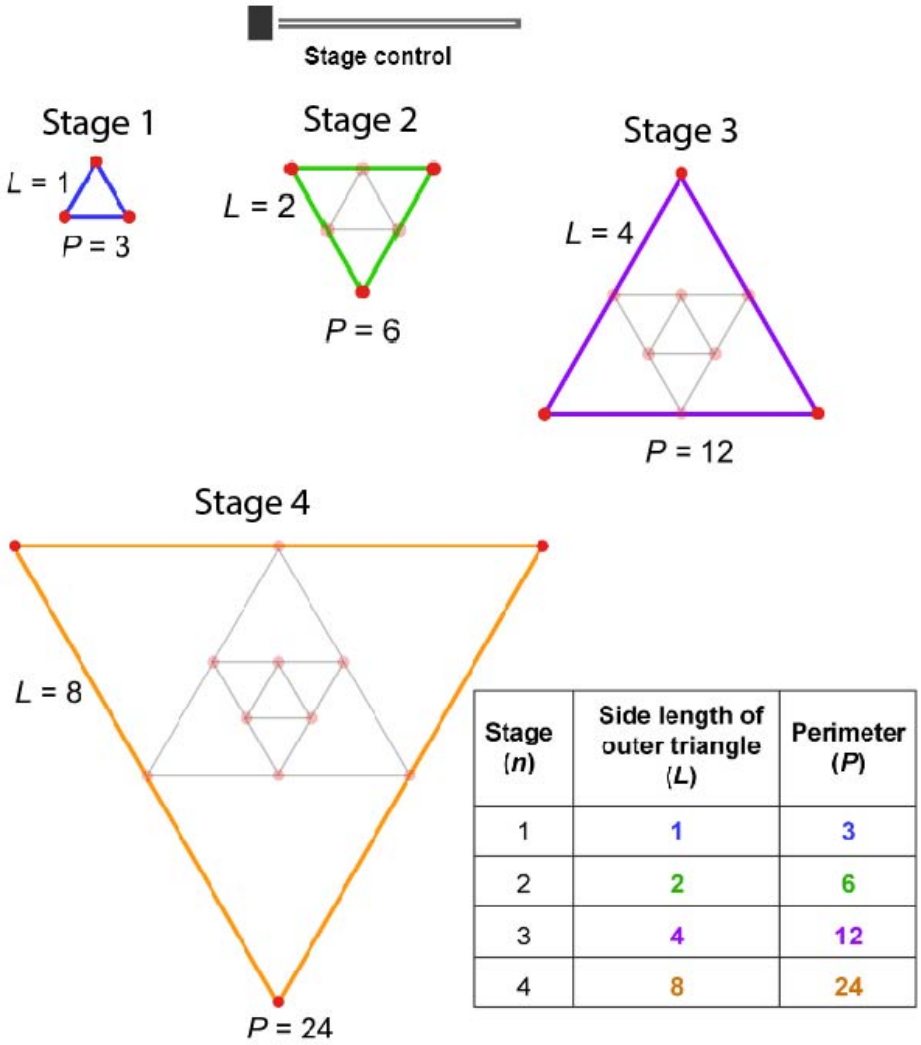
Question 8e (3 marks)

Verify your general rule for T.

Question 8f (1 mark)

Interact with the stage control to see how the perimeter (P) of the outer triangle increases.

Show that the perimeter of the outer triangle in stage 4 is 24.



Stage (n)	Side length of outer triangle (L)	Perimeter (P)
1	1	3
2	2	6
3	4	12
4	8	24

Question 8g (23 marks)

Investigate the values in the table to find a relationship for the perimeter (P) in terms of n.

In your answer, you should communicate the following in an organized and coherent manner:

- predict more values and record these in the table
- describe in words a pattern in the table for the side length (L)
- describe in words a pattern in the table for the perimeter (P)
- write down a general rule for P in terms of n
- test and verify your general rule for P
- justify your general rule for P in relation to the triangles.

Stage (n)	Side length of outer triangle (L)	Perimeter (P)
1	1	3
2	2	6
3	4	12
4	8	24
5		
6		

Markscheme

May 2022

Mathematics

On-screen examination

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

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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

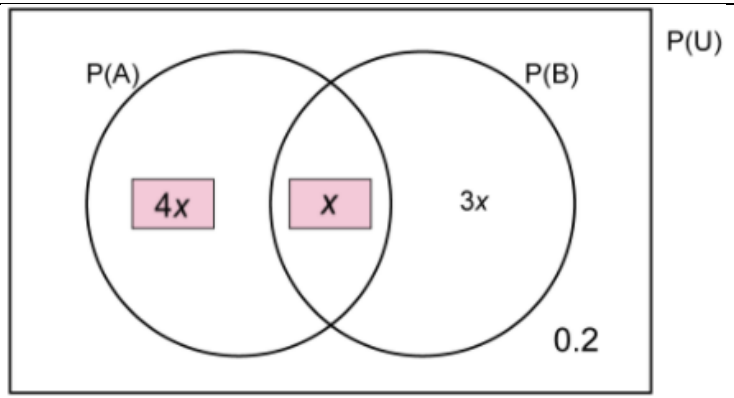
a) As this is an international examination, accept all **alternative forms of notation,** for example 1,9 as 1.9 ; 1,000 or 1.000. However, **DO NOT ACCEPT** incorrect mathematical notation x^2 for x^2 unless noted otherwise in the MS
b) Accept notation errors in intermediate steps.
c) Ignore further 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. $\frac{1}{2}$ **OR** 1/2 **OR** 0.5 **OR** $2 \div 4$ **;** $\frac{x}{2}$ **OR** $x / 2$ or $x \div 2$; 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.
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.

The markscheme abbreviations:

• 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**

Q1	Answers	Notes	Total
a	Correctly place $4x$ and x		**1**
b	The correct answer	$(1-0.2=)0.8$	**1**
c	**AM1** .1 Correct equation .2 Divide their0.8 by 8 .3 The correct answer **AM2** .1 Correctly write a value for $4x$ and $3x$ .2 Subtract 0.7 from their0.8 .3 The correct answer	**AM1** .1 $4x+x+3x=$ their0.8 in part b) or $4x+x+3x+0.2=1$ .2 $\frac{\text{their0.8}}{8}$ .3 0.1 **AM2** .1 0.4 and 0.3 seen .2 their0.8 $-(0.4+0.3)$ .3 0.1	**3**

d	.1 The correct answer .2 The correct reason corresponding to .1 answer and their answer in part c)	.1 Not mutually exclusive ACCEPT They are not .1 ACCEPT they are inclusive .1 ACCEPT "No" only if it is part of a sentence .2 We see their0.1 in this part or in part c) AND we see one of the following reasons → $P(A \cap B) =$ their0.1 → $P(A \cap B) \neq 0$ → they both have x in common → intersection greater than 0 WTTE DO NOT ACCEPT if their0.1 is in terms of x DO NOT ACCEPT if part c) is 0 DO NOT ACCEPT if .1 is not awarded	**2**

Q2		Answers	Notes	Total
	a	**AM1** .1 Correctly substitute into Pythagoras .2 The correct value of AF **AM2** .1 Correctly substitute into trigonometric ratio OR sine rule .2 The correct value of AF	**AM1** .1 $(AF=)\sqrt{10^2-5^2}$ or $AF^2+5^2=10^2$ OE .2 $(AF=)8.66(...)$ ACCEPT 8.7 or 9 or $\sqrt{75}$ or $5\sqrt{3}$ .2 DO NOT ACCEPT 8.67 or 8.6 **AM2** .1 $\tan 30=\frac{5}{AF}$ or $\sin 60=\frac{AF}{10}$ or $\cos 30=\frac{AF}{10}$ OR $\frac{AF}{\sin 60}=\frac{5}{\sin 30}$ OE .1 ACCEPT $(AF=)2\times 5\cos 30$ or $(AF=)2\times 5\sin 60$ or AE =4.33(…) or EF=4.33(…) .2 $(AF=)8.66(...)$ ACCEPT 8.7 or 9 or $\sqrt{75}$ or $5\sqrt{3}$ .2 DO NOT ACCEPT 8.67 or 8.6	**2**

	b	**AM1 (AA or SAS)** .1 A correct reason for a pair of congruent angles .2 A correct reason for another pair of congruent angles (AA) OR The pair of congruent angles are in-between two pairs of proportional sides (SAS) **Continued on next page**	**AM1 (AA or SAS)** **Examples of correct reasons for pair of congruent angles:** → Angle EAD = Angle FAC or Angle A is common angle or same angle A WTTE. (They have to mention the angle A). ACCEPT angle A = angle A → Angle AED = Angle AFC or both right angle triangles or they both have a 90 degrees angle WTTE. ACCEPT both triangles are 30,90,60 WTTE → DE parallel to CF so Angle ADE= Angle ACF or FC is half AC so angle A=30 hence Angle ADE= Angle ACF=60 DO NOT ACCEPT they share same angle or they have a common angle DO NOT ACCEPT Angle EAD and FAC are similar DO NOT ACCEPT seeing only Angle ADE= Angle ACF without correct reasoning **Examples of correct reasons for congruent angles are in-between proportional sides:** → <u>If .1 awarded for Common angle A:</u> $\frac{AC}{AD} = \frac{10}{5} = 2$ and since ADF isosceles and DE perpendicular to AF so $\frac{AF}{AE} = 2$ (or by Thales, AD half AC and DE parallel to CF) **Continued on next page**	**2**

			→ <u>If .1 awarded for angle AED= angle AFC</u> Any two from: $\frac{AC}{AD}=\frac{10}{5}=2$ Angle A=30 so DE=2.5, so $\frac{FC}{DE}=\frac{5}{2.5}=2$ since ADF isosceles and DE perpendicular to AF so $\frac{AF}{AE}=2$ (or by Thales, AD half AC and DE parallel to CF) ACCEPT $\frac{AF}{AE}=\frac{8.66(...)}{4.33(...)}=2$ only if they calculated AE here or in part a) using trigonometry($5\cos 30$ OE)	
		AM2 (SSS) .1 Correctly state reasons for two pairs of corresponding sides being proportional .2 Correctly state reason for third pair of corresponding sides being proportional	**AM2 (SSS)** .1 Two from the reasons below .2 The third from the reasons below (first pair) $\frac{AC}{AD}=\frac{10}{5}=2$ (second pair) Angle A=30 so DE=2.5, so $\frac{FC}{DE}=\frac{5}{2.5}=2$ (third pair) since ADF isosceles and DE perpendicular to AF so $\frac{AF}{AE}=2$ (or by Thales, AD half AC and DE parallel to CF) ACCEPT $\frac{AF}{AE}=\frac{8.66(...)}{4.33(...)}=2$ only if they calculated AE here or in part a) using trigonometry($5\cos 30$ OE)	

	c	**AM1 (Using AF)** .1 The correct ratio seen or used .2 Correctly apply their ratio on their AF .3 The correct value of AE **AM2 (using DE)** .1 Correctly calculate DE .2 Correctly substitute their DE into Pythagoras .3 The correct value of AE **AM 3 next page**	**AM1 (Using AF)** .1 (ratio) 2 or 0.5 OE .2 $\frac{AE}{\text{their}AF} = \frac{1}{2}$ OE .3 (AE =) 4.3(3…) or $\frac{\sqrt{75}}{2}$ OE .3 ACCEPT 4.35 when using $\frac{8.7}{2}$ **AM2 (using DE)** .1 DE = 2.5 .2 $AE^2 + \text{their}2.5^2 = 5^2$ OE or 18.75 .3 (AE =) 4.3(3…) or $\frac{\sqrt{75}}{2}$ OE **Next page for AM 3**	**3**

		AM3 (using trigonometry) .1 Correct angle EAD OR ADE seen or used .2 Correctly substitute their angle into a trig ratio .3 The correct value of AE	**AM3 (using trigonometry)** .1 angle EAD = 30 OR angle ADE =60 .2 $\cos(\text{their}30)=\frac{AE}{5}$ or $\sin(\text{their}60)=\frac{AE}{5}$ OE .3 (AE =) 4.3(3…) or $\frac{\sqrt{75}}{2}$ OE	

Q3		Answers	Notes	Total
	a	.1 The correct value of median .2 The correct weight of 12 candies using 15.19	.1 15.19 .1 ACCEPT seeing on the graph vertical line at 15.19 .2 $(15.19\times 12 =)182.28$ .2 ACCEPT 182 or 182.3 only if .1 is awarded	**2**
	b	.1 Subtract 10 and 120 from 150 .2 The correct value of n	.1 150 – 10 – 120 or 150-130 .2 20	**2**
	c	.1 Correctly add 10 to 120 .2 The correct value of k	.1 (120+10=)130 ACCEPT the top 20 WTTE .1 ACCEPT seeing on the graph horizontal line at 130 provided there are no confusions .2 15.26 ACCEPT]15.25, 15.26] .2 ACCEPT 15.25 only if .1 is awarded	**2**

	d	**AM1** .1 Multiply 6 % by 150 .2 Correctly subtract their 9 from 150 .3 Correctly write their corresponding weight **AM2** .1 Subtract 0.06 from 1 .2 Correctly multiply their 0.94 by 150 .3 Correctly write their corresponding weight	**AM1** .1 0.06×150 OE or 9 seen .2 $(150 - \text{their}9 =) \text{their}141$ ACCEPT the top 9 WTTE .2 ACCEPT seeing a horizontal line at [140,145] on the graph provided there are no confusions .3 (weight=) [15.3,15.31] ACCEPT their weight corresponding to their141, even if their141 is 9, but with error within ± 0.005 **AM2** .1 $1 - 0.06$ or 0.94 OE seen .2 $(\text{their}0.94 \times 150 =) \text{their}141$ ACCEPT the top 9 WTTE .2 ACCEPT seeing horizontal line at [140,145] on the graph provided there are no confusions .3 (weight=) [15.3,15.31] ACCEPT their weight corresponding to their141, even if their141 is 9, but with error within ± 0.005	**3**

<table>
<tr><th>Q4</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr>
<td></td>
<td>.1 Correctly select 2 answers
.2 Correctly select another 2 answers
.3 Correctly select a 5th answer
.4 Correctly select the 6th answer</td>
<td>
<table>
<tr><th></th><th>a</th><th>b</th><th>c</th></tr>
<tr><td>f(x)</td><td>Positive</td><td>Negative</td><td>Positive</td></tr>
<tr><td>g(x)</td><td>Negative</td><td>Negative</td><td>Negative</td></tr>
</table>
</td>
<td>4</td>
</tr>
</table>

<table>
<tr><th colspan="2">Q5</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>5</td><td>a</td><td>.1 Correctly determine an angle

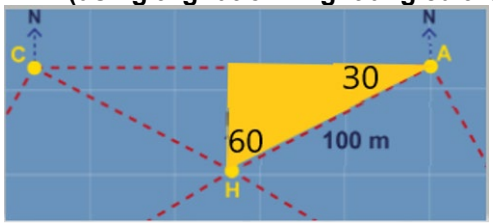
.2 Correctly apply the angle in .1

90 AG</td><td>
<table>
<tr><td>Using</td><td>.1Correctly determine an angle
ACCEPT seeing on the diagram</td><td>.2 Correctly apply the angle from .1</td></tr>
<tr><td>60</td><td>180-60 or 120</td><td>Correctly apply 120:
360-120-150
180-120+180-150
180-120+30</td></tr>
<tr><td>60</td><td>90-60 or 30</td><td>Correctly apply 30:
360-30-90-150
180-30-60</td></tr>
<tr><td>150</td><td>180-150 or 30</td><td>Correctly apply 30:
180-120+30

ACCEPT 60+30=90 only if they explain how they got the 60
Ex:
HAS=NHA
or Alternate (angle)
DO NOT ACCEPT
30+60 corresponding angle
30+60 opposite interior</td></tr>
<tr><td>150</td><td>360-150 or 210</td><td>Correctly apply 210:
210-(180-60)
210-120</td></tr>
<tr><td>150</td><td>150-90=60

Seeing only 60 do not award .1</td><td>Correctly apply 60:
180-60-(90-60)
180-60-30</td></tr>
</table>
DO NOT ACCEPT 150-60=90
DO NOT ACCEPT calculating BH assuming HAB=90 and then finding angles using trigonometry</td><td>2</td></tr>
</table>

	b	**AM1 (using Pythagoras)** .1 Correctly substitute into Pythagoras .2 The correct value of BH after correctly substituting into Pythagoras .3 Correctly round their BH to the nearest metre **AM2 (using cosine rule)** .1 Correctly substitute into cosine rule .2 The correct value of BH after correctly substituting into cosine rule .3 Correctly round their BH to the nearest metre	**AM1 (using Pythagoras)** .1 $BH^2 = 100^2 + 250^2$ or $(BH =)\sqrt{100^2 + 250^2}$ or 72500 OE .2 $(BH =)269(.258...)$ ACCEPT not seeing this step .3 (BH=)their269 .3 ACCEPT their correctly rounded BH only if their BH is not a whole number **AM2 (using cosine rule)** .1 $(BH^2 =)100^2 + 250^2 - 2 \times 100 \times 250 \times \cos 90$ .2 $(BH =)269(.258...)$ ACCEPT not seeing this step .3 (BH=)their269 .3 ACCEPT their correctly rounded BH only if their BH is not a whole number	**3**

	c	**AM1 (using trig ratio in right angled triangle)** .1 Correctly substitute half AC into a trig ratio .2 Correctly calculate half AC .3 Correctly double their .2 .4 Add their values for the correct route .5 Correctly add their values seen in their response for the correct route **AM2 (using cosine rule in triangle AHC)** .1 Correctly substitute into cosine rule .2 Correctly calculate AC^2 .3 Correctly calculate their AC using their cosine rule .4 Add their values for the correct route .5 Correctly add their values seen in their response for the correct route **AM3 next page**	**AM1 (using trig ratio in right angled triangle)**  .1 $\sin 60 = \frac{x}{100}$ or $\cos 30 = \frac{x}{100}$ .2 $100 \times \sin 60$ or $100 \times \cos 30$ or 86.6(025…) ACCEPT 87 .3 $2 \times \text{their}100 \times \sin 60$ or $2 \times \text{their}100 \times \cos 30$ or $2 \times$ their86.6(025) or their173(.20…) ACCEPT their174 .4 their269 + 250 + their173 + 250 + their269 .4 ACCEPT their269 + 250 + AC + 250 + their269 .5 their1211 ACCEPT 1212 **AM2 (using cosine rule in triangle AHC)** .1 $(AC^2 =)100^2 + 100^2 - 2 \times 100 \times 100 \times \cos 120$ OE .2 $(AC^2 =)30000$ or $AC = \sqrt{30000}$ OE .3 (AC=)their173(.20…) .3 ACCEPT their173(.20…) only if they used a cosine rule and not a cosine ratio considering triangle AHC right angled .4 their269 + 250 + their173 + 250 + their269 .4 ACCEPT their269 + 250 + AC + 250 + their269 .5 their1211 **Next page for AM 3 and marks without working**	**5**

		AM3 (using sine rule in triangle AHC) .1 Correctly substitute into sine rule .2 Correctly re-arrange for AC on one side after using sine rule correctly .3 Correctly calculate their AC using their sine rule .4 Add their values for the correct route .5 Correctly add their values seen in their response for the correct route	**AM3 (using sine rule in triangle AHC)** .1 $\frac{AC}{\sin 120} = \frac{100}{\sin 30}$ OE .2 $(AC =)100 \times \frac{\sin 120}{\sin 30}$ OE .3 (AC=)their173(.20…) .3 ACCEPT their173(.20…) only if they used a sine rule and not a sine ratio considering triangle AHC right angled .4 $\text{their}269 + 250 + \text{their}173 + 250 + \text{their}269$ .4 ACCEPT $\text{their}269 + 250 + AC + 250 + \text{their}269$ .5 their1211 **In any AM, in part c):** ACCEPT their269 seen on diagram and if not then their269 from part 5b ACCEPT the use of 270 instead of 269	

Q6		Answers	Notes	Total
	a	.1 Correct area for two from: square, circle or half mouth seen .2 Correct area for third seen .3 Subtract, at least, their circle from their square .4 The correct answer before rounding AG 196	.1 Two from: 20×20 or 400 , $7^2\pi$ or153.9(…) or 153.86 or 154, $\frac{100}{2}$ or 50 .2 Third from: 20×20 or400 , $7^2\pi$ or153.9(…) or 153.86 or 154, $\frac{100}{2}$ or 50 .3 their400 - their153.9(…) or their400 - their153.9(…) - their50 OE .3 ACCEPT only if .1 is awarded .4 196.06(…) or 196.1 ACCEPT using $\pi = 3.14$ and reaching 196.14 or 196.1 .4 ACCEPT seeing evidence of correct rounding in intermediate steps Examples: 400-154-50=196 if 153.9(…) is seen in their response 400-204=196 if 203.9(...) is seen in their response	**4**
	b	**AM1** .1 Correct length ratio .2 Correct area ratio .3 The correct fraction after applying the area ratio **AM 2 next page**	**AM1** .1 $\frac{37.6}{4.7}$ or 8 or $\frac{1}{8}$ OE .2 $(\frac{1}{8^2}=)\frac{1}{64}$ OE or $(8^2=)64$ OE ACCEPT $(\frac{37.6}{4.7})^2$ .3 $\frac{1184}{64}(=18.5)$ or $\frac{37}{2}$ OE ACCEPT $64\times18.5=1184$ .3 ACCEPT $\frac{1184}{(\frac{37.6}{4.7})^2}$	**3**

		AM2 .1 Correct length ratio .2 Correctly dividing areas .3 Correctly show that area ratio is the square of length ratio AG 18.5	**AM2** .1 $\frac{37.6}{4.7}$ or 8 or $\frac{1}{8}$ OE .2 $(\frac{1184}{18.5}=)64$ or $(\frac{18.5}{1184}=)\frac{1}{64}$ OE ACCEPT $\sqrt{\frac{1184}{18.5}}=8$ .3 $64=8^2$ or $\frac{1}{64}=(\frac{1}{8})^2$ or 64 is square of 8 WTTE .3 ACCEPT ratio of area is the square of ratio of side or length ratio is the square root of area ratio WTTE .3 DO NOT ACCEPT 64 is a multiple of 8	
	c	**AM1 (using equations)** .1 Correctly write the second equation .2 Correct step towards solving the correct equations .3 Correctly solve their equations for one unknown x OR y .4 Correctly write their corresponding value of the other unknown satisfying one of their equations .5 Correctly identify x=24 and y=6 **AM2 next page**	**AM1 (using equations) Note: only .3 and .4 are using their** .1 $2x+5y=80$ ACCEPT using inequality .2 correct substitution: $2x+5\times\frac{x}{4}=80$ or $2\times4y+5y=80$ OR correct coefficients for elimination. Example: 2x+5y=80 and 2x-8y=0 or 8x+20y=320 and -5x+20y=0 .2 DO NOT ACCEPT working with their equations from .1 .3 (x =) their $\frac{320}{13}$ or 24.61(...) OE OR (y =) their $\frac{80}{13}$ or 6.15(…) OE .4 (x =)their $\frac{320}{13}$ or 24.61(...) OE OR (y =) their $\frac{80}{13}$ or 6.15(…) OE .5 x = 24 and y =6 or 24 small (triangles) and 6 big (triangles) **Next page for AM 2, SC and marks without working**	**5**

		AM2 (using numbers) .1 Correctly calculate their area using their numbers of small and big triangles .2 Correctly calculate the area using 24 small triangles and 6 big triangles .3 Correctly calculate the area of painting left .4 Seeing their value of x is 4 times their value of y .5 Correctly identify x = 24 and y = 6 .	**AM2 (using numbers) Note: Only .1 and .4 are using their** .1 $(2\times \text{their}24+5\times \text{their}6=)\text{their}78$ .2 $(2\times 24+5\times 6=)78$ .3 $\left(80-78=\right)2$ (cm^2) .4 their24 is 4 times their6 .5 x = 24 and y = 6 or 24 small (triangles) and 6 big (triangles)	

Q7		Answers	Notes	Total
	a	**AM1** .1 Correctly subtract 1.1 or 1.5 from 6 .2 Divide by 0.4 .3 The correct number of tiers **AM2** .1 Correctly set an equation or an inequality .2 Correctly solve their equation .3 The correct number of tiers **AM3** .1 Multiply their number of tiers by 0.4 .2 Correctly calculate the height of tiers .3 The correct number of tiers	**AM1** .1 (6-1.1=) 4.9 or (6-1.5=)4.5 .2 $\frac{\text{their}4.9}{0.4}$ or 12.25 ACCEPT $\frac{\text{their}4.5}{0.4}$ or 11.25 .3 12 (tiers) **AM2** .1 $1.1+0.4n=6$ or $1.5+0.4n=6$ ACCEPT using inequality .2 (n=)their12.25 or their11.25 .3 12 (tiers) **AM3** .1 0.4 x their12 or 4.8 or 4.4 seen .1 ACCEPT repetitively adding 0.4 Ex: 1.1,1.5,1.9,..etc .1 ACCEPT the height increases by 0.4 each time WTTE .2 $(1.1+\text{their}4.8 \text{ or } 1.5+\text{their}4.4=)5.9$ .3 12 (tiers)	**3**

	b	**AM1** (Solving for x) .1 Correctly write the equation in terms of x .2 Correctly rearrange the equation .3 The correct value of x before rounding down x=5 AG **AM2** (using x=5) .1 Correctly set calculations for width .2 Correctly calculate one of: -width of sections and gaps -total width excluding gaps -the remaining distance .3 Correct argument that x=5 is the maximum possible in the width of 30	**AM1** (solving for x) .1 $3.5x+1.5\times(x-1)+2\times2=30$ OE ACCEPT using inequality .2 $5x=27.5$ ACCEPT $5x+2.5=30$ ACCEPT using inequality .3 $(x=\frac{27.5}{5}=)5.5$ **AM2** (using x=5) .1 Two from $\rightarrow 5\times3.5$ OE $\rightarrow 4\times1.5$ OE $\rightarrow 2\times2$ OE or $30-2\times2$ OE .2 One of the following is seen $\rightarrow(5\times3.5+4\times1.5+2\times2=)27.5$ ACCEPT width of sections and in-between gaps $(5\times3.5+4\times1.5=)23.5$ $\rightarrow(30-4\times1.5-2\times2=)20$ $\rightarrow(30-5\times3.5-4\times1.5-2\times2=)2.5$ .3 A corresponding argument from (WTTE): $\rightarrow\frac{27.5}{5}=5.5$ or add another section and recognise that total is more than 30 $\rightarrow\frac{20}{3.5}=5.7(1...)$ or add another section and recognise that total is more than 30 $\rightarrow$ Recognise 2.5 remaining	**3**

7c) total 10 marks

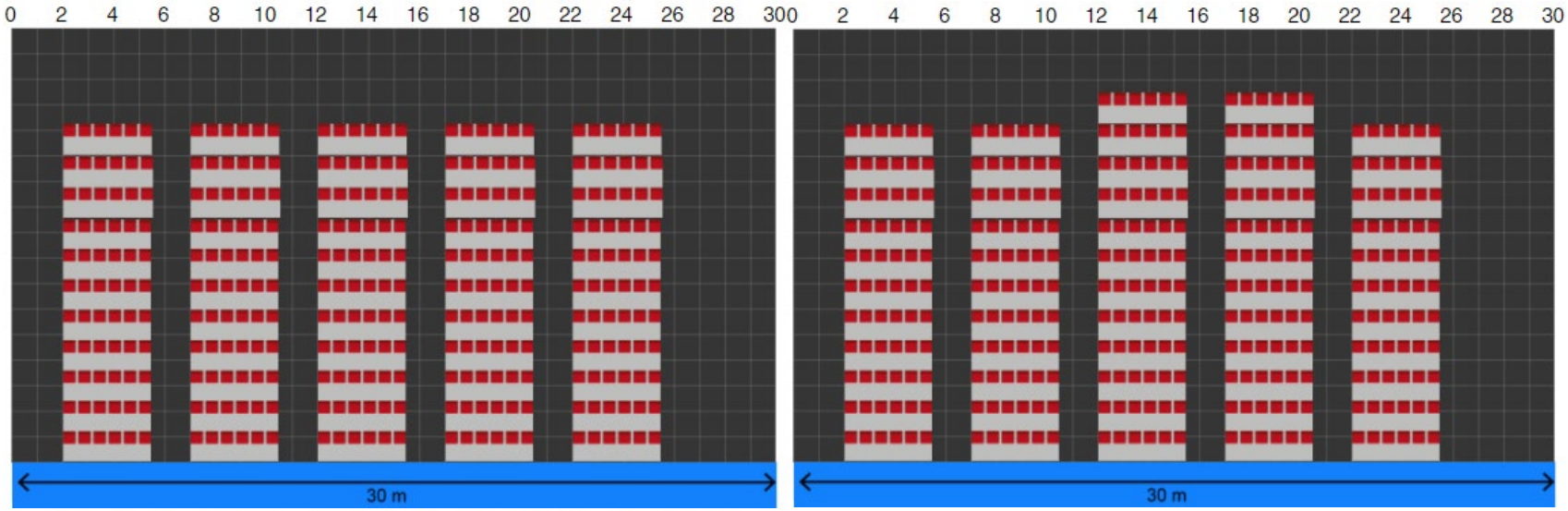
	(1 mark)	(2 marks)	(3 marks)	(4 marks)
Factors (F)	**Two** factors seen in factors box from (WTTE): - number of seats in a row or in a section, number of sections, or width of section(s) - number of tiers or height - total number of seats or capacity of theatre -width of theatre or space available -Gaps that must be left (either in-between or at the ends) ACCEPT using values for any of the above DO NOT ACCEPT only "number of seats" as a factor	**Three** factors seen in factors box from (WTTE): - number of seats in a row or in a section, number of sections, or width of section(s) - number of tiers or height - total number of seats or capacity of theatre -width of theatre or space available -Gaps that must be left (either in-between or at the ends) ACCEPT using values for any of the above DO NOT ACCEPT only "number of seats" as a factor		
Cal (C)	**Correct calculations for their number of seats in a row or in a block** Total seats per row: 5×6 or 30 ACCEPT $\frac{348}{12} = 29$ OE **OR** Total seats in one of their blocks Ex: 8×6 or 48 12×6 or 72 **OR** Number of sections of seats: $\frac{348}{6} = 58$	**Correct calculations related to the total number of seats in the range [120,420]** Total number of seats 30 multiplied by their number of tiers: Example: $30 \times 4 = 120$ **OR** Number of tiers: Their total number of seats divided by 30 Ex: $\frac{348}{30} = 11.6$ **OR** Number of blocks of seats: Their total number of seats divided by 6 times their number of tiers Ex: $\frac{348}{78}$ (78=6x13) more on next page	**Correct calculations for total number of seats in the range [330,360]** **EITHER** $11 \times 30 = 330$ **OR** $12 \times 30 = 360$ ACCEPT if they make further step and reach total number of seats in the range [330,360] Ex: $12 \times 30 - 10 = 350$ ACCEPT correct combinations using blocks for a total of 330 or 360 $66 \times 5 = 330$ or $72 \times 5 = 360$ OE	**Correct calculations for a total number of 348 seats** **EITHER** $11 \times 30 = 330$ then $330 + 3 \times 6 = 348$ **OR** $12 \times 30 = 360$ then $360 - 2 \times 6 = 348$ **OR** ACCEPT correct combinations using blocks for a total of 348 Ex: $72 \times 3 + 66 \times 2 = 348$ OE or $72 \times 4 + 60 = 348$ OE or $48 \times 5 + 24 \times 4 + 12 = 348$ OE DO NOT ACCEPT $29 \times 12 = 348$

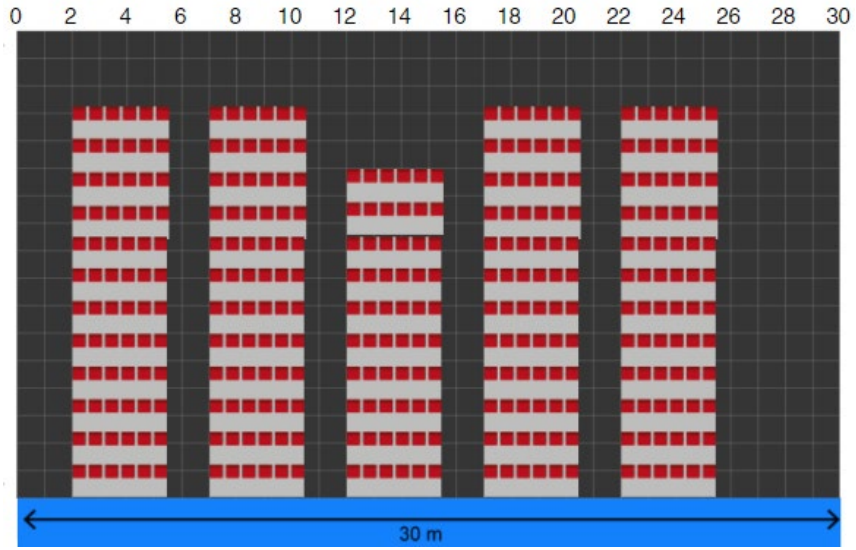
		ACCEPT correct combinations using blocks for a total in the range [120,420] Ex: 5 × 24 = 120 ACCEPT listing number of seats per block for a total in the range [120,420] Ex: 48,48,48,48,24,24,24,24 DO NOT ACCEPT 29 × 12=348	ACCEPT listing number of seats per block only if total is 348 Ex: 48,48,48,48,48,24,24,24,24,12 DO NOT ACCEPT 29 × 12=348	
Justify (J)	**Weak justification** **Awareness of effect of constraints** I made the best use (or didn't make the best use) of space within the constraint(s) WTTE ACCEPT for the constraints if they list at least one constraint DO NOT ACCEPT if C0 and D0 are awarded	**Good justification** I made the best use (or didn't make the best use) of space within the constraint(s) WTTE ACCEPT for the constraints if they list at least one constraint **AND** I have blocks of different sizes that do not exceed 12 tiers WTTE (seen on canvas or in calculations) DO NOT ACCEPT if C0 and D0 are awarded		
Design (D)	**Two from:** Gaps between sections ≥1.5 Gaps left and right ≥2 330 ≤Total number of seats≤ 348 Tiers ≤12 ACCEPT number of seats seen in response box different from number on canvas ACCEPT error in the gaps up to 0.25 m DO NOT ACCEPT if their total number of seats on canvas is less than 120	**The four of:** Gaps between sections ≥1.5 Gaps left and right ≥2 330 ≤Total number of seats≤ 348 Tiers ≤12 ACCEPT number of seats seen in response box different from number on canvas ACCEPT error in the gaps up to 0.25 m		

For examples of marks for the design (D) scroll down

Accepted for D2

Gaps between sections ≥ 1.5 AND Gaps left and right ≥ 2 AND $330 \leq$ Total number of seats ≤ 348 AND tiers ≤ 12





<table>
<tr><th colspan="3">Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>8</td><td>a</td><td>Recognize there are <u>four</u> triangles and an <u>outer one</u></td><td>4 triangles inside a big one WTTE
Examples to ACCEPT
1 is outline for all 4 triangles
4 small and 1 big
4 triangles in one triangle
4 triangles make up (or joined to make) the 5th
A big triangle and 4 sub-triangles
4 triangles that create a perimeter of a new one
3 triangles added to original then an outer one

Examples that we DO NOT ACCEPT
it starts by one and adds 4 each time WTTE
all dots connected to create a big triangle
triangles all together make 5
A big triangle and small triangles
entire triangle counted as one and includes sub-triangles</td><td>1</td></tr>
<tr><td></td><td>b</td><td>Correctly place 17 and 21</td><td><table><tr><th>Stage
(n)</th><th>Number of triangles
(T)</th></tr><tr><td>1</td><td>1</td></tr><tr><td>2</td><td>5</td></tr><tr><td>3</td><td>9</td></tr><tr><td>4</td><td>13</td></tr><tr><td>5</td><td>17</td></tr><tr><td>6</td><td>21</td></tr></table></td><td>1</td></tr>
<tr><td></td><td>c</td><td>·1 Correctly describe one pattern in words
·2 Correctly describe a second pattern in words

More on next page</td><td>ACCEPT complete terminology only, for example (below are four different descriptions)
(T) goes up by 4, increases by 4, moves up by 4, adds 4
They are odd numbers
Linear with difference 4, arithmetic with difference 4, Constant difference 4
Second difference is zero

DO NOT ACCEPT incomplete terminology, for example:
Arithmetic, linear, increasing by a constant, constant difference, the odd numbers

DO NOT ACCEPT the rule in words, for example:
4 times n then subtract 3</td><td>2</td></tr>
</table>

			The difference between 4*n* and 3 DO NOT ACCEPT *n* goes up by 1 It is increasing general rules in terms of *n*, example: $T = 4n - 3$ More than two different patterns, all correct award **(2 marks)** Ex: adds 4 and Second difference is zero and it is 4 times *n* minus 3 More than two different patterns, with any incorrect award **(1 mark)** Ex: adds 4 and Second difference is zero and it is 4 times *n*	
	d	·1 The correct general rule ·2 The correct simplified general rule with correct notation	·1 $4n - 3$ or T=4**n*-3 or $u_n = 4n - 3$ or t=4*n*-3 or T=2*n*+2*n*-3 or T=4*x*-3 ·2 $T = 4n - 3$ or $T_n = 4n - 3$ DO NOT ACCEPT description in words	**2**
	e	·1 Correctly substitute $n \geq 5$ into their general rule ·2 Correctly calculate their value of *T* after substituting $n \geq 5$ ·3 Recognize that their result is the same as the correctly predicted value	·1 Ex: $4 \times 7 - 3$ ·2 Ex: 25 (for the $n = 7$) .3 "the same as when we continue the pattern" WTTE and states how Ex: For *n*=7, 25 is obtained from pattern of adding 4 to 21 ·3 ACCEPT if their value from .2 is the same as their value in the table in part a) or seen here in part e)	**3**
	f	3×8 or $8 + 8 + 8$ 24 AG	ACCEPT in words Ex: It is the tripple of 8 or 3 times 8 DO NOT ACCEPT 2×12 OE	**1**

8	g		23

Mark	1	2	3	4	5
Predictions (P)	Correctly predict one value for P **OR** two values for L	Correctly predict two values for *P* **OR** one value for *P* and two for *L*	Correctly predict two values for *P* **AND** two values for *L*		
Description (D)	Correctly describe a pattern in words or recursive rule or rule (for *L or P)* **Examples for *L* and *P*:** Value doubles WTTE The difference doubles Increasing by multiplying by 2 Exponential Geometric Goes up by the previous number **Examples for *L*:** All even except 1 Add 1 then add 2 then add 4,...etc OE The recursive rule for *L* Ex: $L(n)=L(n\text{-}1)\times 2$ **Examples for *P*:** All even except 3 Add 3 then add 6 then add 12,..etc OE Multiples of 3 The recursive rule for P Ex: $P(n)=P(n\text{-}1)\times 2$ DO NOT ACCEPT *P* is increasing *P* is triple of *L* or Valid attempt to write down a general rule for *L* Examples: $L = 2^n$ DO NOT ACCEPT $L=2n$ or The rule for *P:* $P=3L$ Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words or recursive rule or rule for *L* and for *P* **OR** Correctly describe a pattern in words or recursive rule or rule (for *L* or *P*) and valid attempt to write down a general rule for *L* Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words or recursive rule or rule for *L* and for *P* and valid attempt to write down general rule for *L* **OR** Correctly write down the general rule for *L* $L = 2^{n-1}$ **OR** Valid Attempt to write down a general rule for *P* Examples: (seeing in their rule added or multiplied by something) $P = 3\times 2^n$ $P = 2^n + 2n$ DO NOT ACCEPT $P = 2^n$ $P = 2\times 3^n$ or $P = 3\times 1.86^n$ $P = 3\times$ their general rule for *L* $P = 3n$ Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words or recursive rule or rule (for *L* or *P*) and correctly write down the general rule for *L* **OR** Correctly describe a pattern in words (for *L* or *P*) or recursive rule or rule for L and valid attempt to write down a general rule for *P* **OR** Correctly write down the general rule for *P* $P = 3\times 2^{n-1}$ or $P = 1.5\times 2^n$ Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words or recursive rule or rule for *L* and for *P* **AND** Correctly write down the general rule for *P* Ignore additional incorrect patterns (for Notation see N)

Testing (T)	Attempt to test their general rule for P using $n \leq 4$ Correctly substitute in their general rule for P a value of $n \leq 4$ **OR** Correctly test their general rule for L or described pattern or recursive rule **OR** Correctly test their rule for P or described pattern or recursive rule ACCEPT testing the rule $P=3L$ or testing their general rule for L	Correctly test their general rule for P using $n \leq 4$ Correctly calculate their value for P in their general rule using $n \leq 4$ **AND** Recognize that their correctly calculated value for P is the same as the given value. ACCEPT seeing their correctly calculated value for P and the given value in the table being equal			
Verifying (V)	Attempt to verify their general rule for P using $n \geq 5$ Correctly substitute in their general rule for P a value of $n \geq 5$ **OR** Correctly verify their general rule for L or described pattern or recursive rule **OR** Correctly verify their rule for P or described pattern or recursive rule ACCEPT verifying the rule $P=3L$ or verifying their general rule for L	Correctly calculate their value for P in their general rule using $n \geq 5$	Correctly calculate their value for P in their general rule using $n \geq 5$ **AND** Recognise that their correctly calculated value for P is the same as their predicted value obtained by continuing the pattern ACCEPT seeing their correctly calculated value for P and their predicted value in the table being equal		

Justify/ proof (J)	Weak attempt to justify their general rule (for *L* or *P*) or described pattern or rule or recursive rule Examples: trying at least two more values and arguing as justification that they are the same or rule works or seeing their rule for $P=3\times$ their general rule for *L* OE DO NOT ACCEPT if D2 not achieved	Good attempt to justify their general rule (for *L* or *P)* Examples <u>seen as justification</u>: We multiply by 2 every time or It is geometric with ratio 2 or They have a rule for *L* in terms of *n* and they say there is 3 in the rule of *P* because *P*=3*L* OE DO NOT ACCEPT if D3 not achieved	Correctly justify the general rule for *L* Examples: First term is 2^0, second is 2^1 so it makes sense that *n*th term is 2^{n-1} OE or recognize it is geometric progression with ratio 2 and first term 1 **OR** correctly justify the general rule for *P* algebraically Examples: First term is 3×2^0, second is 3×2^1 so it makes sense that nth term is $3\times 2^{n-1}$ OE or They assume $P=a\times 2^n$ and substitute to find the correct value of *a* or recognize it is geometric progression with ratio 2 and first term 3 ACCEPT seeing the justification inside their work and not separate at the end DO NOT ACCEPT if D3 not achieved	Correctly justify the general rule for *P* in relation to geometry Correctly justify the general rule for *L* AND recognise *P*=3*L* OE ACCEPT seeing the justification inside their work and not separate at the end DO NOT ACCEPT if D4 not achieved	

Communication criteria

Mark	1	2	3
Notation and terminology (N)	Correct notation of <u>their general</u> rule **OR** Correct terminology describing a pattern **OR** The notation of <u>the general</u> rule for L or P includes errors DO NOT ACCEPT if they don't have any rules and they don't describe correctly any pattern	Correct notation of <u>the general</u> rule for L or P **OR** The notation of <u>the general</u> rule for L or P includes errors and Correct terminology describing a pattern in words DO NOT ACCEPT if they don't have the general rule for L or P For notation of the general rule for L $L = 2^{n-1}$ ACCEPT Using U_n instead of L only if they mention that $L = U_n$ non simplified rules ex : $L = \frac{2^n}{2}$ OE DO NOT ACCEPT using * for multiplication using / for division using ^ for power Using x instead of n The rule for L is 2^{n-1}	Correct notation of <u>the general</u> rule for P **AND** Correct terminology describing pattern in words for P DO NOT ACCEPT if they don't have the general rule for P For notation of the general rule for P $P = 3 \times 2^{n-1}$ or $P = 3(2)^{n-1}$ or $P = 3.2^{n-1}$ $P = 3\ 2^{n-1}$ ACCEPT using U_n instead of P only if they mention that $P = U_n$ non simplified rules ex: $P = \frac{3}{2} \times 2^n$ DO NOT ACCEPT using * for multiplication using / for division using ^ for power Using x instead of n The rule for P is $3 \times 2^{n-1}$

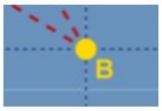
Mark	1	2	3
Communication (L) Organisation and coherence Can be awarded even if there are errors **Different items can be considered seen (or identified for coherence) if they include errors but not if awarded 0 marks**	**At least three** from the following items are seen: · describe a pattern in words · write a rule · test their general rule or rule or recursive rule or pattern · verify their general rule or rule or recursive rule or pattern · justify their general rule or rule or recursive rule or pattern (at least J1 awarded)	DO NOT ACCEPT if they don't have a general rule (in terms of n) **At least four** of the following items are seen: · describe a pattern in words (for L or P) · write a general rule (for L or P) · test their general rule (for L or P) · verify their general rule (for L or P) · justify their general rule (for L or P) (at least J1 awarded) **AND** For coherence, they identify the processes correctly. **At least one** from the following: · test · verify · justify 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**	DO NOT ACCEPT if they don't have The general rule for P **At least four** of the following items are seen: · describe a pattern in words · write the general rule for P · test the general rule for P · verify the general rule for P · justify the general rule for P (at least J2 awarded) **AND** For coherence, they identify the processes correctly. **At least two** from the following: · test · verify · justify 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 J2 awarded**

The table of values and rules:

Stage (n)	Side length of outer triangle (L)	Perimeter (P)
1	1	3
2	2	6
3	4	12
4	8	24
5	16	48
6	32	96
7	64	192
8	128	384

	Side length of outer triangle (L)	Perimeter (P)
General rules	$L = 2^{n-1}$	$P = 3 \times 2^{n-1}$

Question 1 (4 marks)



Knowing and understanding

In this task (questions 1 to 5), you will interact with different aspects of **form** using a variety of related concepts. This task focuses on **criterion A** (Knowing and understanding) and **criterion C** (Communication).

Compare mean and standard deviation in different distributions.

Question 2 (8 marks)

Find probabilities of combined events.

Question 3 (7 marks)

Use properties of triangles to find lengths.

Question 4 (4 marks)

Use properties of exponentials to determine the unknown values in equations.

Question 5 (11 marks)

Use bearings and networks to find angles, distances and the shortest route.

Question 6 (12 marks)



Applying mathematics in real-life contexts

In this task (questions 6 and 7), you will use **relationships** to apply mathematics within the global context of **personal and cultural expression**. This task focuses on **criterion D** (Applying mathematics in real-life contexts) and **criterion C** (Communication).

Find areas and lengths in cultural masks.

Question 7 (21 marks)

Explore relationships between tiered seating and the space available in a theatre.

Question 8 (33 marks)



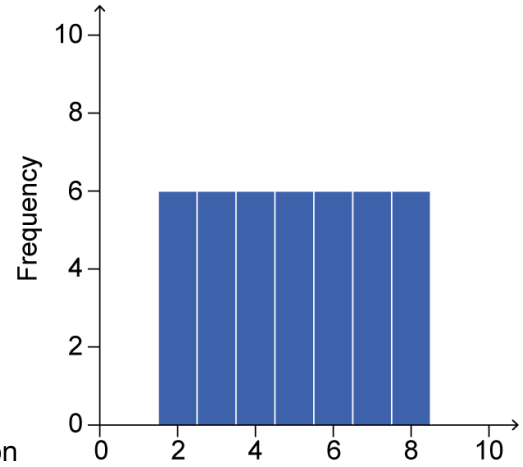
Investigating patterns

In this task (question 8), you will use **logic** to investigate the formation of triangular patterns. You will be assessed using **criterion B** (Investigating patterns) and **criterion C** (Communication).

Describe patterns and find general rules for the area of triangular formations.

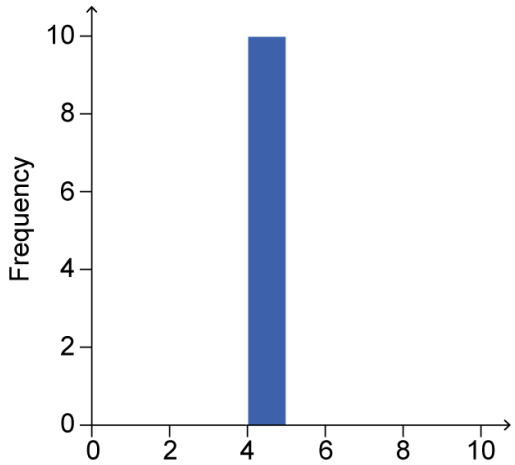
Question 1 (4 marks)

Select the term from the drop-down menu which correctly describes the distribution of each graph.



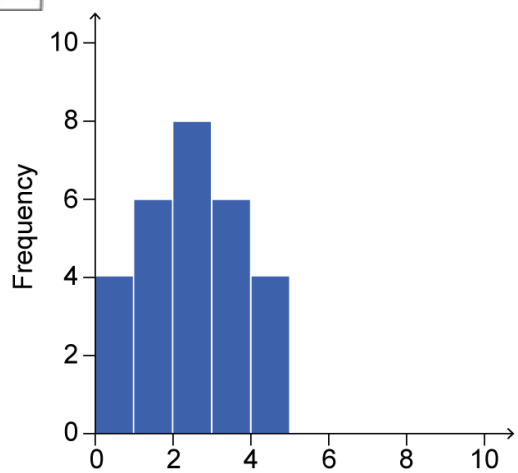
Select
Zero
Large

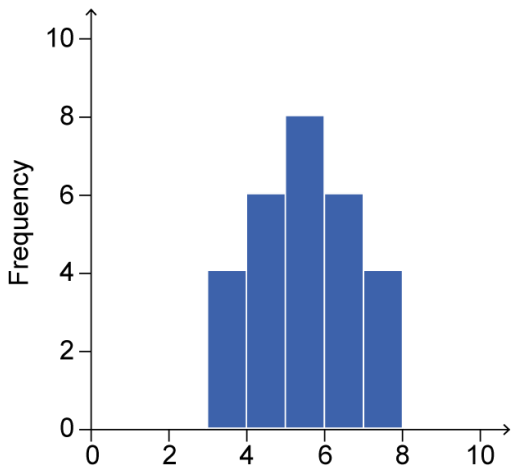
standard deviation



Select
Zero
Large

standard deviation





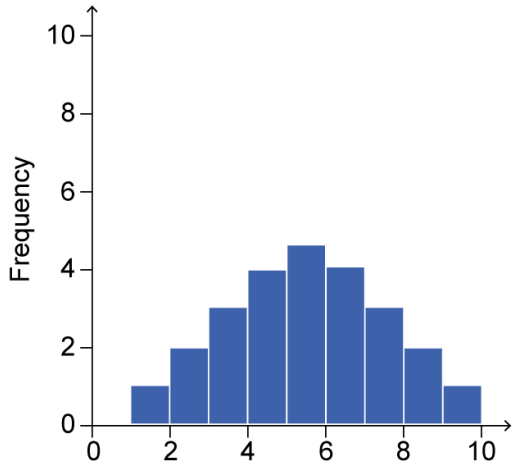
Select
Same
Different

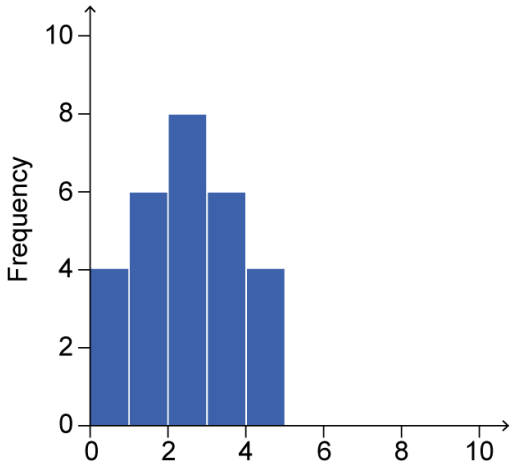
mean

Select
Same
Different

standard deviation

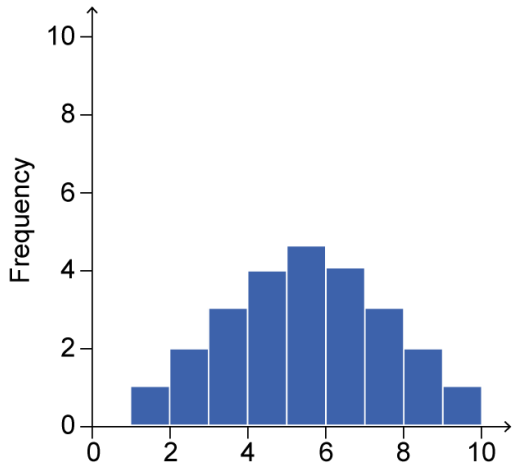
Scroll down to continue

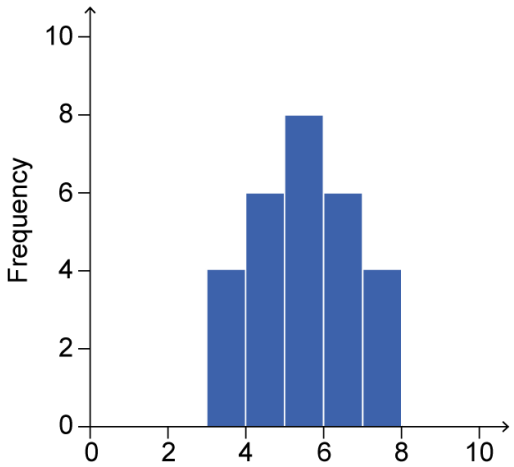




Select
Same
Different
mean

Select
Same
Different
standard deviation





Select
Same
Different
mean

Select
Same
Different
standard deviation

Scroll down to continue

Question 2 (8 marks)

Two events, A and B, are such that $P(A) = \frac{18}{25}$, $P(A \mid B) = \frac{2}{3}$ and $P(A \cap B) = \frac{8}{25}$.

Question 2a (3 marks)

Find P(B).

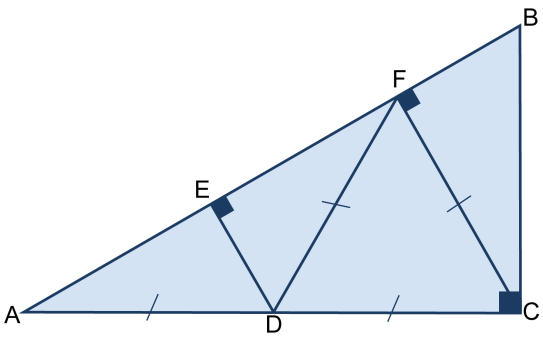
Question 2b (3 marks)

Show that events A and B are not independent.

Question 2c (2 marks)

Find $P(A \cup B)$.

Question 3 (7 marks)



Given that AD = DC = DF = FC = 5 m:

Question 3a (2 marks)

Determine the length of AF.

Question 3b (2 marks)

Show that triangle AFC is similar to triangle ACB.

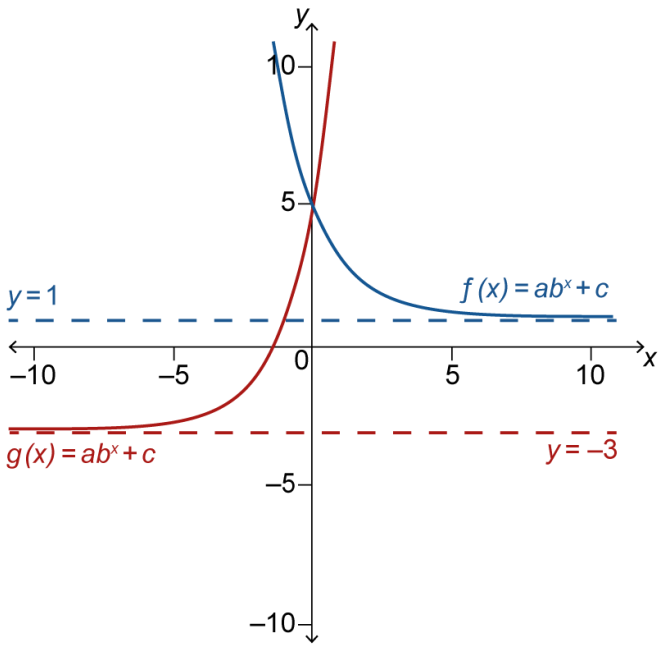
Question 3c (3 marks)

Hence, **find** the length of AB.

Scroll down to continue

Question 4 (4 marks)

The functions, $f(x)$ and $g(x)$, are shown in the graph below.



The values of a, b and c are different for $f(x)$ and $g(x)$.

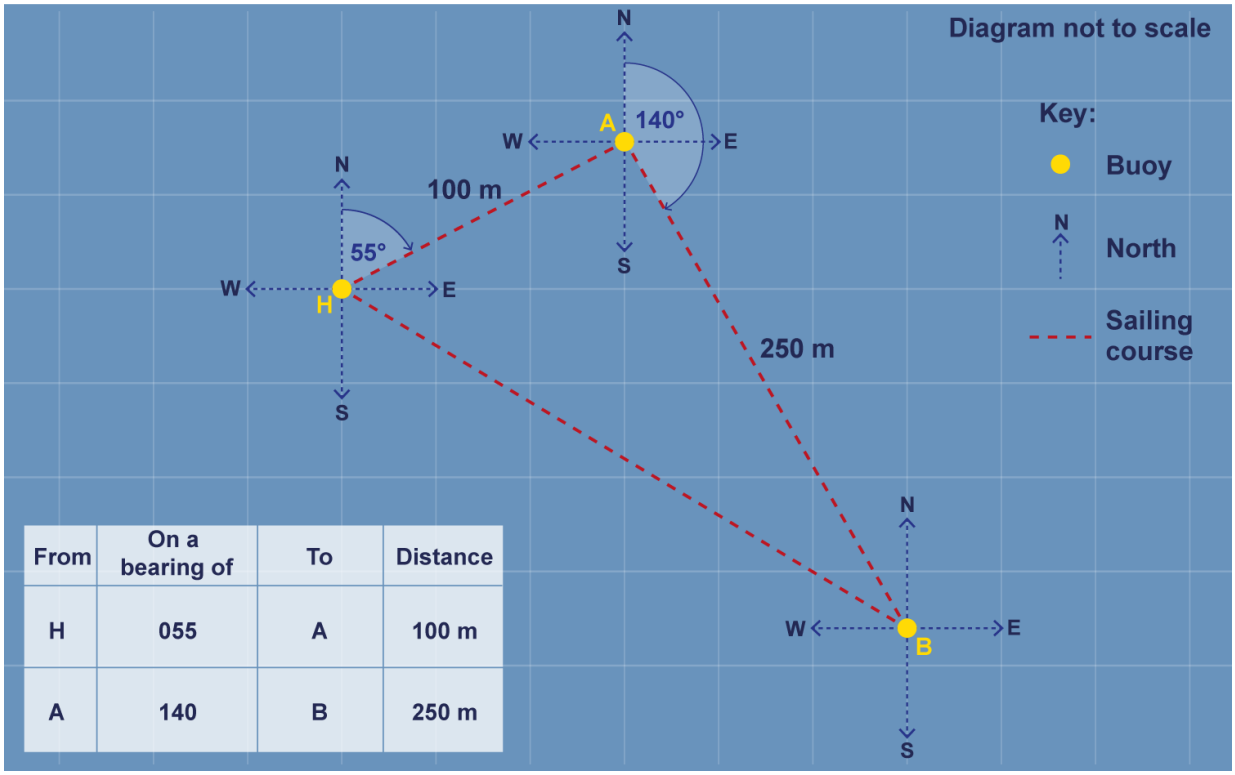
Select the correct values to complete the table. Use the draggable values provided.

Draggable items:		a	b	c
–3 0.5 1 4 8	f(x)			
	g(x)		2	

Scroll down to continue

Question 5 (11 marks)

The diagram below shows a sailing course for a yacht race. The route for the course is laid out with buoys that the yachts must pass. The details of the sailing course are provided in the table.



From	On a bearing of	To	Distance
H	055	A	100 m
A	140	B	250 m

Question 5a (2 marks)

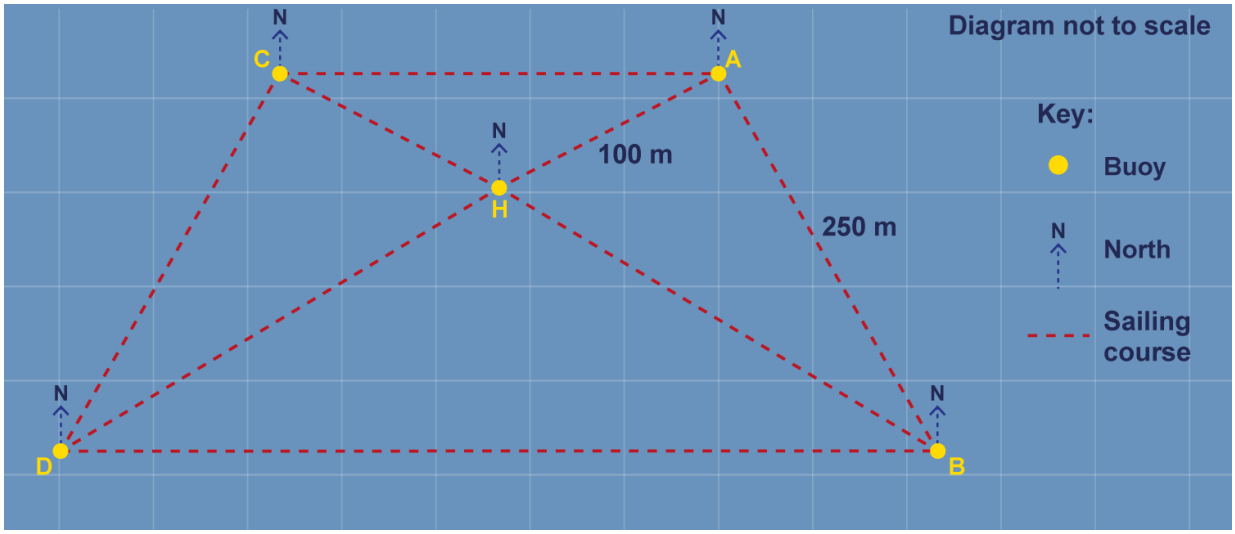
Show that the size of the angle HAB is 95 degrees.

Question 5b (3 marks)

Calculate the distance from B to H.

Scroll down to continue

The course for the yacht race is made longer by setting two more buoys at C and D. They are set as a reflection of buoys A and B respectively, on the vertical line passing buoy H.



The race will start from buoy H and the yachts must pass all the buoys exactly once and return to H.

Question 5c (1 mark)

Write down the route with the minimum total distance.

Question 5d (5 marks)

Hence, **find** this minimum total distance.

Scroll down to continue

Question 6 (12 marks)



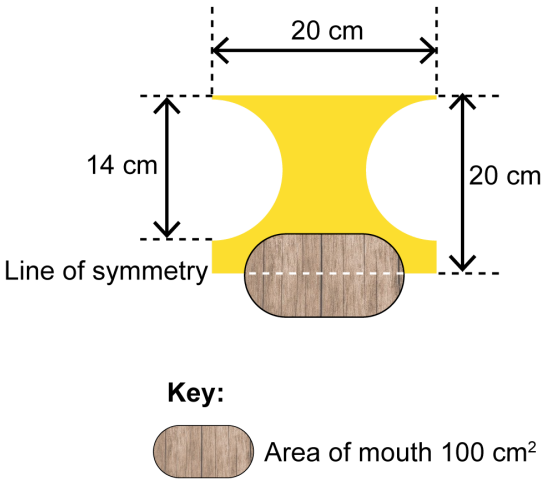
"In Africa, masks serve an important role in rituals or ceremonies with varied purposes like ensuring a good harvest, addressing tribal needs in time of peace or war, or conveying spiritual presences in initiation rituals or burial ceremonies."

©

Question 6a (4 marks)

A designer is creating two masks, Mask A and Mask B. They are created using geometrical shapes and symmetrical properties. Interact with the stage control to see how Mask A is created.

Mask A



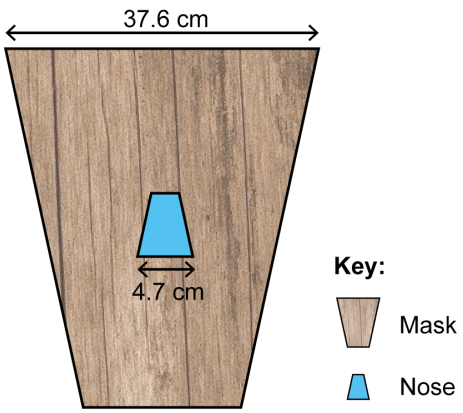
Show that the area in yellow is 196 cm^2 to the nearest whole number.

Question 6b (3 marks)

The wooden template for Mask B is shown below.

Mask B

Diagram not to scale



For artistic purposes, the designer wants the mask and nose to be in the shape of **similar** trapeziums.

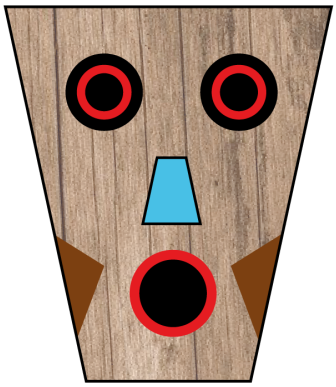
The area of the mask is 1184 cm^2. **Show that** the area of the nose is 18.5 cm^2.

Question 6c (5 marks)

The decoration of Mask B is not complete; the designer will now add triangles of two sizes using yellow paint.

Mask B is decorated with the following instructions:

- the yellow paint available can cover a total area of 80 cm^2
- use yellow paint to add triangles of two sizes
  - small triangle with area of 2 cm^2
  - big triangle with area of 5 cm^2
- the number of small triangles must be equal to 4 times the number of big triangles



Key:
Area of triangles

2 cm^2

5 cm^2

Given that:

x : number of small triangles
y : number of big triangles
$x = 4y$

Given that there is only 80 cm of yellow paint available, **find** the maximum number of small and big triangles that can be added to the mask.

Scroll down to continue

Question 7 (21 marks)

Video | Script

Theatre performances are an important form of how society gathers to enjoy and appreciate creative expression. The first examples of theatre performances are thought to date back as far as the 6th century BCE.

Theatre seating is designed to ensure that audiences can enjoy performances from anywhere in the space. Tiered seating is proven to provide the best experience.

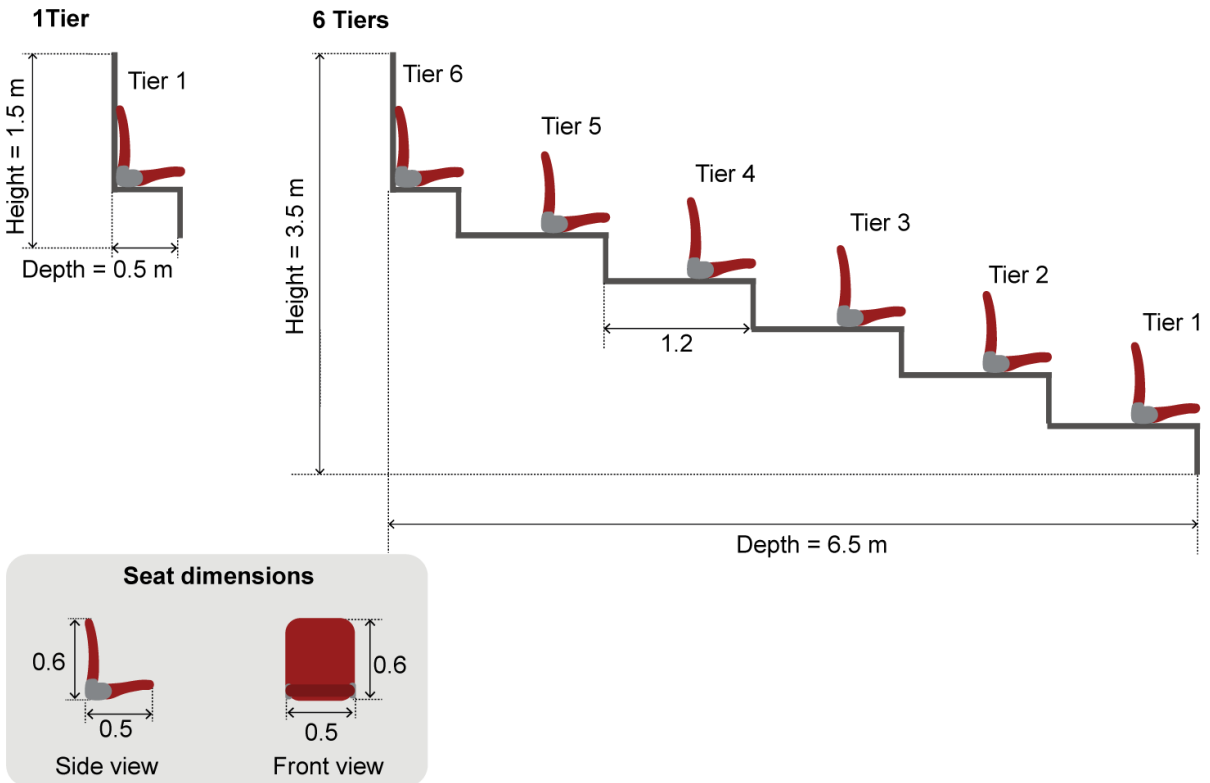
Many small theatres use mobile tiered seating that can be folded away when not in use. Here we have an example of a tiered seating design.

The manufacturers of the mobile seating systems must adhere to the following safety requirements when producing the seating:

- there must be safety barriers on the side and back of the seating
- the tiered seating must not be above 6 metres high.
- six seats are connected to create sections of seats.
- there must be a gap of 1.5 metres between sections of seats.
- and there must be exit spaces of at least 2 metres on each side of the tiered seating.

In this question you will explore the possible designs for tiered seating for this theatre space.

Below is a cross-sectional view of tiered theatre seating.



Question 7a (2 marks)

In the tiered seating illustrated above, the height of the first tier is 1.5 m, the height of the sixth tier is 3.5 m. The heights of the tiers form an arithmetic sequence.

Determine the value of the common difference between heights of tiers.

Scroll down to continue

Question 7b (1 mark)

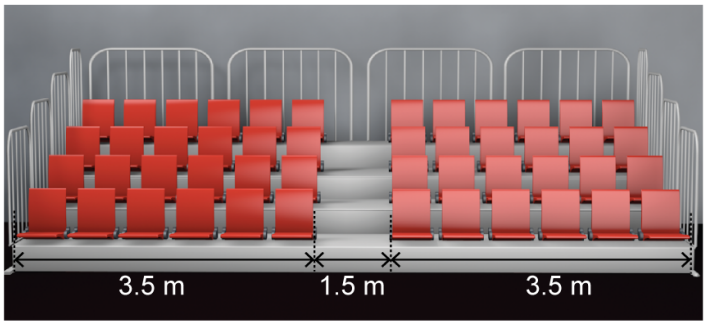
Write down the general term to determine the height (H_n) of the tiered seating in the nth row.

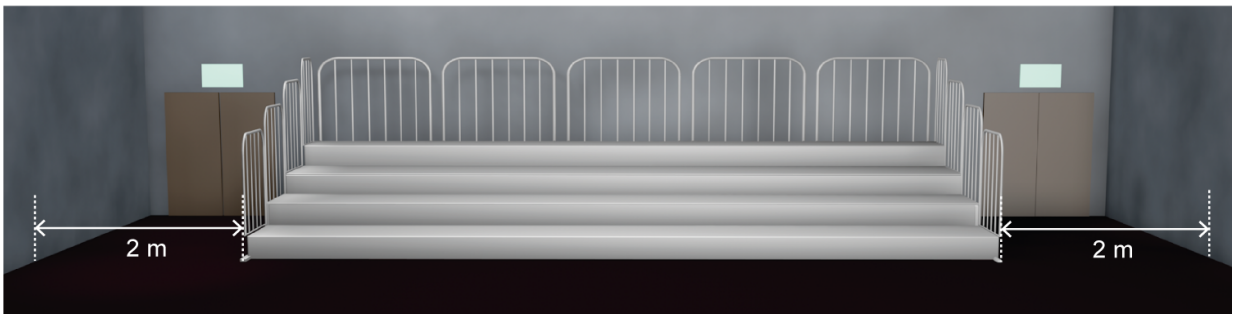
Question 7c (2 marks)

Determine the height of **twelve** tiers.

Question 7d (3 marks)

Each section of seating is 3.5 m wide. For access and safety a 1.5 m gap must be left between each section of seating and 2 m at the ends of each side.





Let x represent the maximum possible number of sections of seating per row that will fit in a theatre of width of 30 m.

Show that $x = 5$.

Scroll down to continue

Question 7f ((10 marks)

The maximum seating capacity for the theatre is 348.

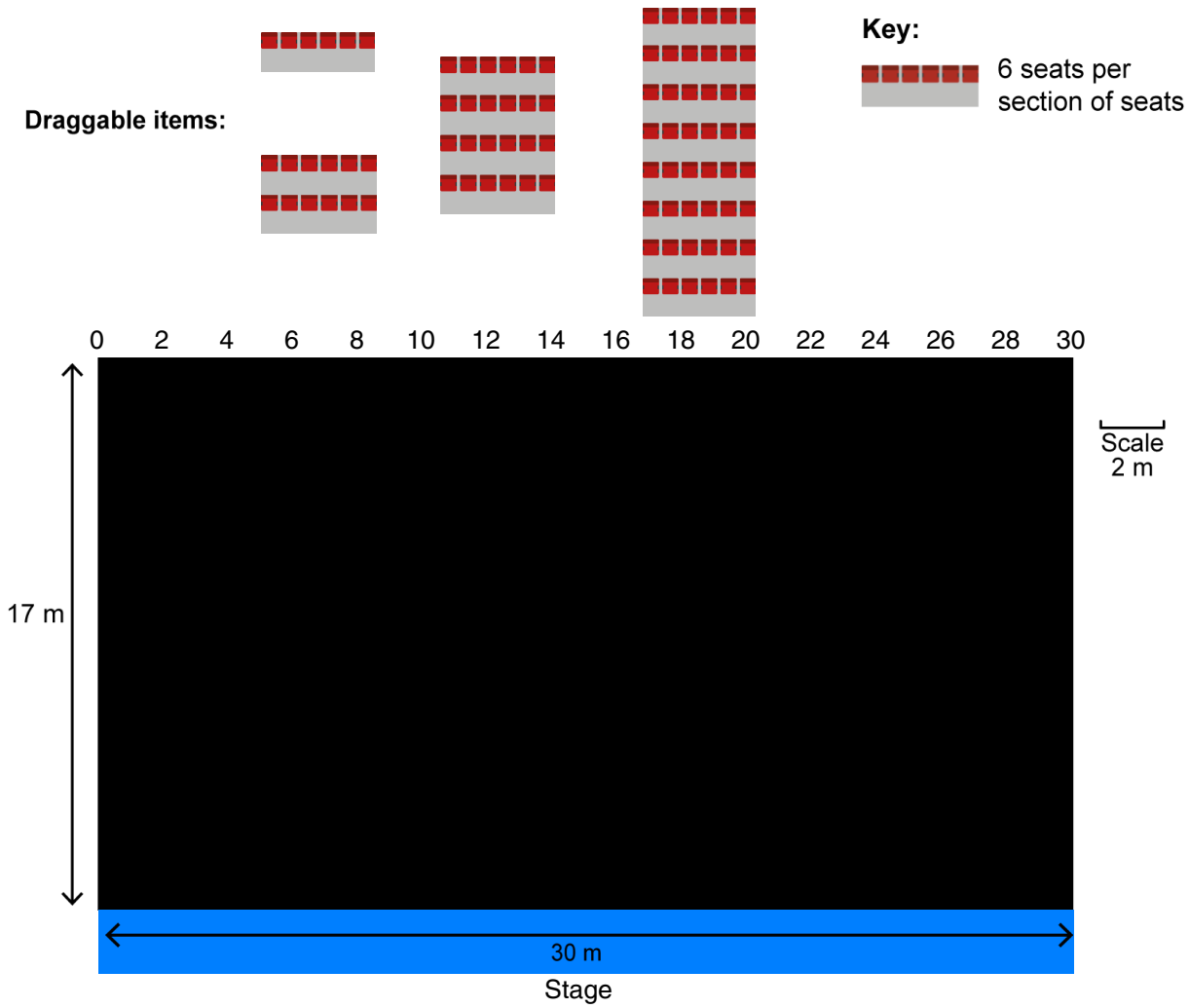
Using the constraints and your answers from previous parts, **design** tiered seating for the theatre for the maximum number of people.

In your answer you should:

- clearly identify **three** relevant factors
- make calculations for the number of seats per row
- make calculations for the number of seats for the whole tiered seating
- use the canvas to illustrate your design
- justify whether your design makes the best use of the theatre space.

Three relevant factors

Calculations and justification



Question 7e (3 marks)

x represents the number of sections of seating per row

y represents the number of tiers

Below are the constraints for the theatre

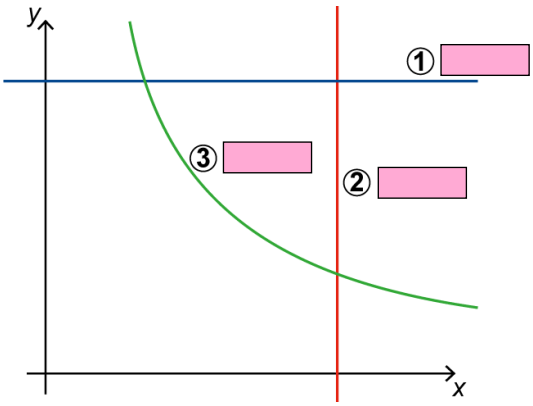
Constraint 1: The horizontal width of the theatre is 30 m
Constraint 2: The vertical height of the tiers must be at most 6 m
Constraint 3: The maximum seating capacity for the theatre is 348

Using your answers from previous parts:

- **label** the equations of line ①, line ② and line ③
- **identify** the region that satisfies all constraints.

Draggable items:

Region

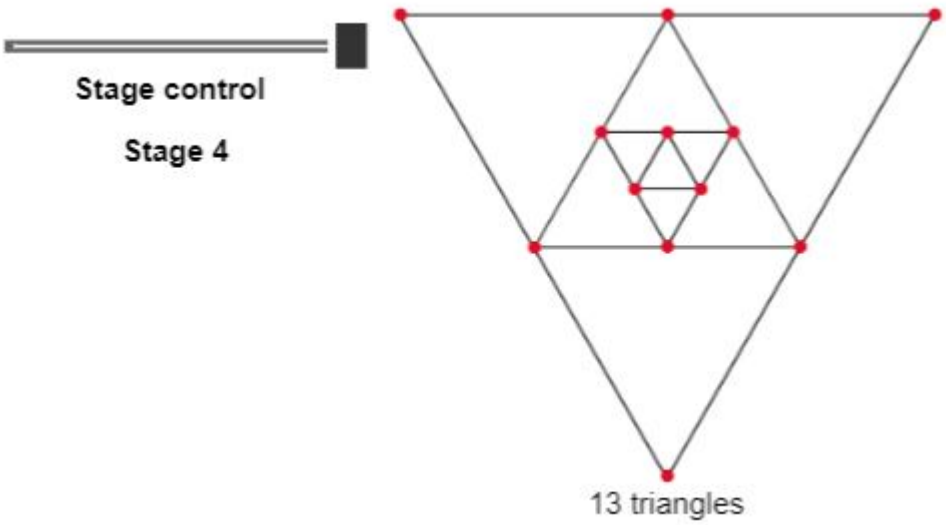


Scroll down to continue

Question 8 (33 marks)

In this task you will investigate triangles.

Interact with the stage control to see how the equilateral triangles are formed.



The table below shows number of triangles in each stage.

Stage (n)	Number of triangles (T)
1	1
2	5
3	9
4	13

Question 8a (2 marks)

Describe in words two patterns in the table for the number of triangles (T).

Question 8b (2 marks)

Write down a general rule for T in terms of n.

Question 8c (3 marks)

Verify your general rule for T.

Stage (n)	Number of triangles (T)
1	1
2	5
3	9
4	13

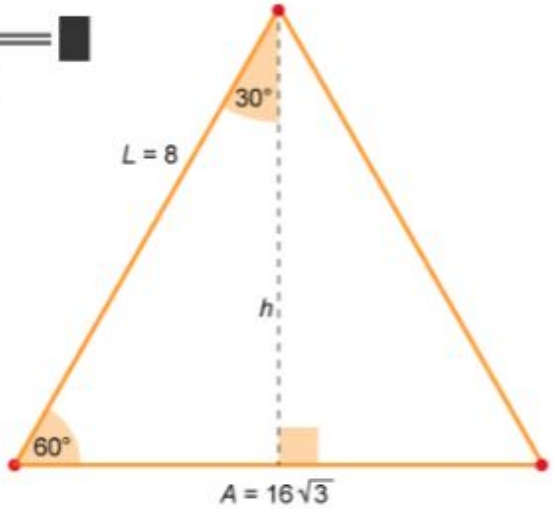
Scroll down to continue

Question 8d (3 marks)

Interact with the stage contol to see how the area (A) of the outer triangle increases.



Stage 4



Stage (n)	Side length of outer triangle (L)	Area (A)
1	1	$\frac{\sqrt{3}}{4}$
2	2	$\sqrt{3}$
3	4	$4\sqrt{3}$
4	8	$16\sqrt{3}$

Show that the area of the outer triangle in stage 4 is $16\sqrt{3}$.

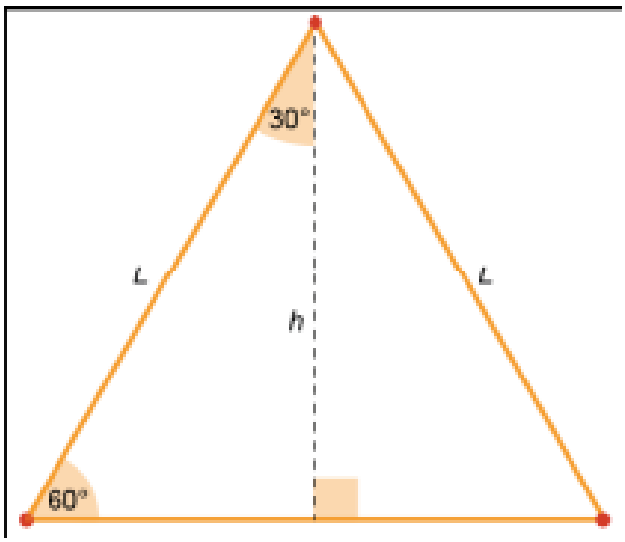
Question 8e (23 marks)

Investigate the values in the table to find a relationship for the area (A) in terms of n.

In your answer, you should communicate the following in an organized and coherent manner:

- predict more values and record these in the table
- describe in words a pattern in the table for the side length (L)
- describe in words a pattern in the table for the area (A)
- write down a general rule for A in terms of n
- test and verify your general rule for A
- justify your general rule for A in relation to the triangles.

Stage (n)	Side length of outer triangle (L)	Area (A)
1	1	$\frac{\sqrt{3}}{4}$
2	2	$\sqrt{3}$
3	4	$4\sqrt{3}$
4	8	$16\sqrt{3}$
5		
6		



Scroll down to continue

Markscheme

May 2022

Extended mathematics

On-screen examination

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The markscheme abbreviations:

• 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

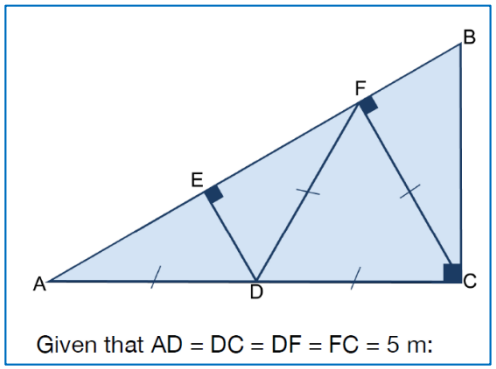
a) As this is an international examination, accept all **alternative forms of notation,** for example 1,9 as 1.9 ; 1,000 or 1.000. However, **DO NOT ACCEPT** incorrect mathematical notation x^2 for x^2 unless noted otherwise in the MS
b) Accept notation errors in intermediate steps.
c) Ignore further 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. $\frac{1}{2}$ **OR** 1/2 **OR** 0.5 **OR** $2 \div 4$ **;** $\frac{x}{2}$ **OR** $x / 2$ or $x \div 2$; 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.
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
	.1 **First** and **Second** graph descriptions correct .2 First comparison (third and fourth graphs) both correct .3 Second comparison (fifth and sixth graphs) both correct .4 Third comparison (seventh and eighth graphs) both correct	.1 Text/MCQ/Mini-Cloze Object Large standard deviation Text/MCQ/Mini-Cloze Object Zero standard deviation .2 Text/MCQ/Mini-Cloze Object Different mean Same standard deviation .3 Text/MCQ/Mini-Cloze Object Different mean Different standard deviation .4 Text/MCQ/Mini-Cloze Object Same mean Different standard deviation	**4**

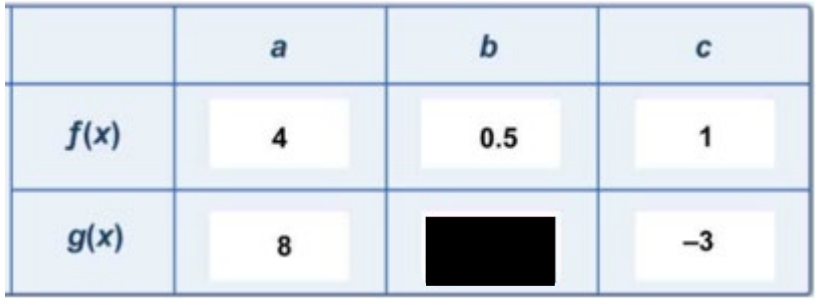
Q2		Answers	Notes	Total
		$P(A)=\frac{18}{25}$, $P(A\mid B)=\frac{2}{3}$ and $P(A\cap B)=\frac{8}{25}$		
	a	.1 Correctly substitute into the conditional probability formula $P(A\mid B)=\frac{P(A\cap B)}{P(B)}$ OR recognize that $\frac{8}{25}$ is $\frac{2}{3}$ of P(B) .2 Correct working step using their substitution into conditional probability formula OR correct calculations from 8/25 being the 2/3 of P(B). .3 Their correct answer after working steps using the conditional probability formula or the logic behind $\frac{8}{25}$ being the $\frac{2}{3}$ of P(B)	.1 $\frac{2}{3}=\frac{8}{25}\div P(B)$ OE OR $\frac{8}{25}$ is $\frac{2}{3}$ of $P(B)$ .2 (P(B)=) $\frac{8}{25}\div\frac{2}{3}$ OE .3 (P(B)=) their $\frac{12}{25}$ OE .3 ACCEPT only if their P is less than 1.	**3**
	b	**AM1** .1 Evidence of using the rule for independent events .2 Correctly calculate P(A) x theirP(B) .3 Correctly state their product does not equal to $P(A\cap B)$ **AM2** .1 Evidence of using P(A) and P(A|B) .2 $\frac{18}{25}$ and $\frac{2}{3}$ seen .3 Acknowledge that $\frac{18}{25}$ and $\frac{2}{3}$ are not equal	**AM1** .1 $P(A\cap B)$ and $P(A)\times P(B)$ seen or $\frac{8}{25}$ and $\frac{18}{25}\times$ their $\frac{12}{25}$ seen OE .2 their $\frac{216}{625}$ OE .3 their $\frac{216}{625}\neq\frac{8}{25}$ OE ACCEPT their $\frac{216}{625}\neq P(A\cap B)$ .3 DO NOT ACCEPT if there is no calculated product **AM2** .1 $P(A)=P(A\mid B)$ **ACCEPT not seeing this step** .2 $\frac{18}{25}$ and $\frac{2}{3}$ **seen** .3 $\frac{18}{25}\neq\frac{2}{3}$ or $\frac{18}{25}$ not equal to $\frac{2}{3}$ ACCEPT $P(A)\neq P(A\mid B)$	**3**
	c			**2**

		.1 Correctly substitute into the addition rule $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ .2 Their correct answer after using addition rule	.1 $\frac{18}{25} + \text{their}\frac{12}{25} - \frac{8}{25}$ .2 their $\frac{22}{25}$ OE .2 ACCEPT only if their P is less than 1 or equal to 1.	

Q3		Answers	Notes	Total
	a	**AM1** .1 Correctly substitute into Pythagoras .2 The correct value of AF **AM2** .1 Correctly substitute into trigonometric ratio OR sine rule OR cosine rule .2 The correct value of AF	**AM1** .1 $(AF =)\sqrt{10^2 - 5^2}$ or $AF^2 + 5^2 = 10^2$ OE .2 ACCEPT 8.7 or $\sqrt{75}$ or $5\sqrt{3}$ .2 DO NOT ACCEPT 8.67 or 8.6 or 9 **AM2** .1 $\tan 30 = \frac{5}{AF}$ or (AF=)10xcos30 or (AF =) 10sin60 OE OR $\frac{AF}{\sin 120} = \frac{5}{\sin 30}$ or $\frac{AF}{\sin 60} = \frac{5}{\sin 30}$ OE OR $(AF^2 =) 5^2+5^2-2(5)(5)\cos 120$ OE or $(AF^2=) 10^2+5^2-2(10)(5)\cos 60$ OE .1 ACCEPT $(AF =)2 \times 5\cos 30$ or $(AF =)2 \times 5\sin 60$ or AE =4.33(…) or EF=4.33(…) .2 (AF =) 8.66(…) ACCEPT 8.7 or $\sqrt{75}$ or $5\sqrt{3}$ .2 DO NOT ACCEPT 8.67 or 8.6 or 9	**2**

	b	.1 A correct reason for a pair of congruent angles .2 A correct reason for another pair of congruent angles  Given that AD = DC = DF = FC = 5 m:	**Examples of correct reasons for pair of congruent angles:** For angle A: → Angle BAC = Angle FAC → Angle A is common angle → They share same angle A WTTE (they have to mention angle A) ACCEPT angle A = angle A DO NOT ACCEPT they share same angle or they have a common angle DO NOT ACCEPT Angle BAC is similar to Angle FAC For the 90 degrees angle → Angle ACB = Angle AFC → They both have a 90 degrees angle → Both right angle triangles WTTE ACCEPT they are both 30-60-90 triangles DO NOT ACCEPT angle F = angle C For the 60 degrees angle → FC is half AC so angle A=30 hence ABC= Angle ACF=60 DO NOT ACCEPT seeing only Angle ABC= Angle ACF DO NOT ACCEPT without correct justification	**2**

	c	**AM1 (Using proportions)** .1 Their correct ratio using AC and theirAF seen or used .2 Correctly apply their ratio on AC .3 Their correct value for AB **AM2 (trigonometry using AC)** .1 Correct angle ABC OR BAC seen or used .2 Correctly substitute their angle into trigonometric ratio .3 Their correct value for AB **AM3 (trigonometry FB and AF or Pythagoras AC)** .1 Correct angle BCF OR CBF seen or used .2 Correctly substitute their angle into trigonometric ratio .3 Their correct answer for AB using theirBF added to theirAF or using Pythagoras with AC and theirBC.	**AM1** .1 $\frac{\text{theirAF}}{\text{AC}} = \frac{\text{their8.66}}{10}$ (= 0.866…) or $\frac{\text{AC}}{\text{theirAF}} = \frac{10}{\text{their8.66}}$ (= 1.1547…) OE .2 $10 \times \text{their1.1547…}$ or $\frac{10}{\text{their0.866}}$ .2 DO NOT ACCEPT if their ratio is 2 or $\frac{1}{2}$ .3 (AB =) their 11.547(005…) ACCEPT 11.5 or 11.55 **AM2** .1 (BAC=)30 OR (ABC=) 60 .2 $\sin\text{their60} = \frac{10}{\text{AB}}$ or $\cos\text{their30} = \frac{10}{\text{AB}}$ OE ACCEPT $\frac{10}{\sin\text{their60}}$ or $\frac{10}{\cos\text{their30}}$ OE .3 (AB=) their11.547(005…) ACCEPT 11.5 or 11.55 **AM3** .1 (BCF=)30 or (CBF=)60 .2 $\tan\text{their30} = \frac{\text{BF}}{5}$ OE or $\sin\text{their60} = \frac{5}{\text{BC}}$ OE or BC = $\frac{5}{\cos\text{their30}}$ OE .2 ACCEPT (BF=) 2.89 or 2.9 or (BC=) 5.77 .3 (their8.66 + their2.89 =) their11.547(005…) ACCEPT 11.5 or 11.55	**3**

Q4	Answers	Notes	Total
	.1 One correct .2 A second correct .3 A third correct .4 The fourth and fifth correct		**4**

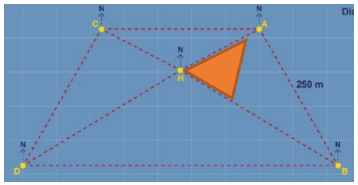
	a	*b*	*c*
$f(x)$	4	0.5	1
$g(x)$	8	[redacted]	–3

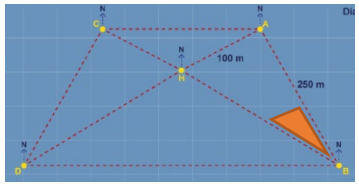
Q5		Answers	Notes	Total
	a	**Important note: Candidates may use a correct method but not listed below. Mark it in-line with any of these methods. If in doubt contact your team leader for advice.** **AM1 (55 as an alternate interior angle)** ·1 Correctly subtract 55 from 180 ·2 Subtract the sum of 125 and 140 from 360 95 AG **AM2 (55 as an alternate interior angle)** ·1 Correctly subtract 140 from 360 ·2 Subtract the difference of 180 and 55 from 220 95 AG **AM3 (supplementary angle and alternate interior angle)** .1 Correctly subtract 140 from 180 .2 Add 55 and 40 95 AG **AM4 (complementary angle and alternate interior angle)** .1 Correctly subtract 55 from 90 .2 Correctly subtract the sum of 35, 90 and 140 from 360 95 AG **AM5 (bearing of H from A)** .1 Correctly determine bearing of H from A .2 Correctly subtract 140 from 235 95 AG	**AM1** ·1 $180-55$ or 125 ·2 $360-(125+140)$ ACCEPT $140+125+95=360$ .2 ACCEPT 360 – 265 only if .1 is awarded **AM2** ·1 360 – 140 or 220 ·2 220 – (180 – 55) or 220 –125 **AM3** .1 180 – 140 or 40 .2 55 + 40 **AM4** .1 90 – 55 or 35 .2 360 – (35 + 90 + 140) ACCEPT 270 – (150 + 35) ACCEPT 360 – 265 only if .1 is awarded **AM5 (bearing of H from A)** .1 180 + 55 = 235 DO NOT ACCEPT only seeing 235 .2 235 – 140	**2**

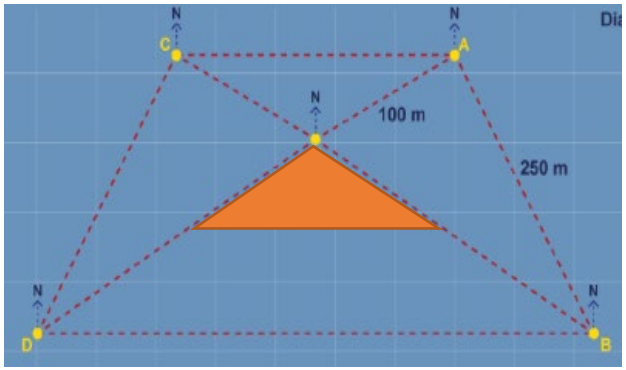
	b	·1 Correctly substitute into cosine rule ·2 Correctly calculate the square of BH ·3 Correctly square root their result	·1 $(x^2 =)100^2 + 250^2 - 2 \times 100 \times 250 \times \cos 95$ OE ·2 76857(.787...) ACCEPT not seeing this step ·3 their 277(.232...)	**3**
	c	·1 Correctly identify the shortest route	·1 HABDCH or HCDBAH ACCEPT HBACDH or HDCABH	**1**

<table>
<tr><td>5</td><td>d</td><td colspan="2">SPECIAL NOTE 1
Even though candidate may have a route that does not include BD, marking to ensure fairness and consistency must be made following all the steps.

SPECIAL NOTE 2
If candidates use both AC and BD in c) they will make calculations for both distances in d) – identify the distance that will give the most marks and ignore the other distance calculation. However for .5 when they find the total distance, they must calculate the sum using their AC and BD found in d).</td></tr>
<tr><td>5</td><td>d</td><td>.1 Correct method to calculate
angle AHB or angle ABH

AHB


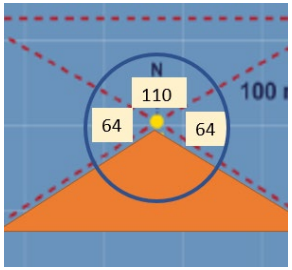
ABH


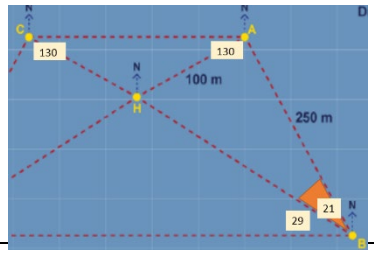
.2 Their correct angle BHD (bottom)

</td><td>.1
<table><tr><th>AHB</th><th>ABH</th></tr><tr><td>$\frac{\sin AHB}{250}=\frac{\sin 95}{\text{their}277}$ OE

$250^2 = 100^2 + \text{their}277^2 - 2(100)(\text{their}277)\cos(AHB)$

AHB=64(.0390602)</td><td>$\frac{\sin ABH}{100}=\frac{\sin 95}{\text{their}277}$ OE

$100^2 = 250^2 + \text{their}277^2 - 2(250)(\text{their}277)\cos(ABH)$

ABH = 21(.0779…)</td></tr></table>
.2
<table><tr><th>Using their AHB</th><th>Using their ABH</th></tr><tr><td>360–110–2(their64) or
(BHD=) their 122

</td><td>(Trapezium total :360)
(Upper angles 130)
(Lower angles $\frac{1}{2}$(360-2(130)) = 50)
(HBD = 50–their21 = their29)

180 – 2(their29) or
(BHD=) their122

</td></tr></table>
.2 DO NOT ACCEPT 110 for angle BHD for .2</td></tr>
</table>

		.3 Correct substitute into cosine rule to get BD or AC **OR** Correct substitute into a correct trig ratio to get half BD or half AC **OR** correct substitute into sine rule to get BD or AC .4 Correct calculate their BD or AC .5 Correct add their values for their route	.3 $(BD^2 =)\text{their}277^2 + \text{their}277^2 - 2(\text{their}277)(\text{their}277)\cos\text{their}122$ or $(AC^2 =)100^2 + 100^2 - 2(100)(100)\cos 110$ ACCEPT use of 110 in .3 for their BHD or 55 for half BHD $(BD^2 =)\text{their}277^2 + \text{their}277^2 - 2(\text{their}277)(\text{their}277)\cos 110$ **OR** $\sin 61 = \frac{\text{half BD}}{\text{their}277}$ or $\sin 55 = \frac{\text{half BD}}{\text{their}277}$ or $\sin 55 = \frac{\text{half AC}}{100}$ OE **OR** $\frac{BD}{\sin 122} = \frac{\text{their}277}{\sin 29}$ or $\frac{BD}{\sin 110} = \frac{\text{their}277}{\sin 35}$ or $\frac{AC}{\sin 110} = \frac{100}{\sin 35}$ OE .4 (BD=) Their484.5(393178…) or 453.81(02325…) seen (AC=) 163.8(30…) Correct .4 implies .3 . 5 Correct answer 1184.5 or 1185 (100+250+their484.5+250+100=) their1184.5 or their 1185 (100+250+their453.8+250+100=) their1153.8 or their 1154 (their 277+250+their163.8+250+their 277=) their1217.8 or their 1218 .5 ACCEPT values for their route in part c) even if route is incorrect .5 DO NOT ACCEPT if their route is incomplete (ex : doesn't end at H)	

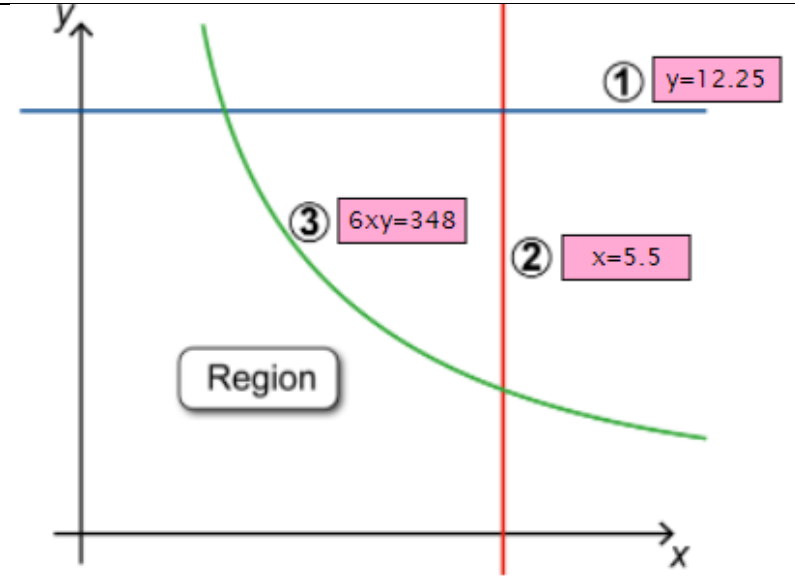
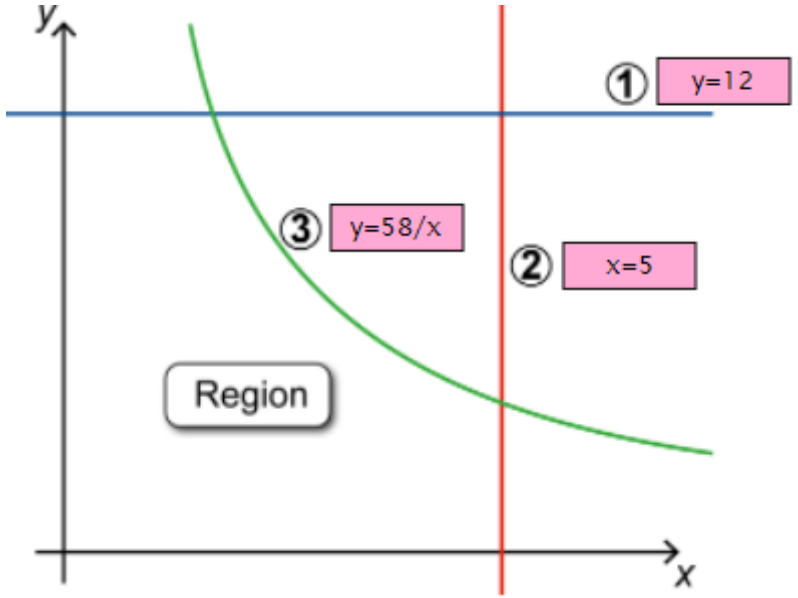
Q6		Answers	Notes	Total
	a	.1 Correct area for two from: square, circle or half mouth seen .2 Correct area for third seen .3 Subtract, at least, their circle from their square .4 The correct answer before rounding AG 196	.1 Two from: 20×20 or 400 , $7^2\pi$ or 153.9(…) or 153.86 or 154, $\frac{100}{2}$ or 50 .2 Third from: 20×20 or 400 , $7^2\pi$ or 153.9(…) or 153.86 or 154, $\frac{100}{2}$ or 50 .3 their400 - their153.9(…) or their400 - their153.9(…) - their50 OE .3 ACCEPT only if .1 is awarded .4 196.06(…) or 196.1 ACCEPT using $\pi = 3.14$ and reaching 196.14 or 196.1 .4 ACCEPT seeing evidence of correct rounding in intermediate steps Examples: 400 – 154 – 50 = 196 if 153.9(…) is seen in their response 400 – 204 = 196 if 203.9(...) is seen in their response	**4**

	b	**AM1** .1 Correct length ratio .2 Correct area ratio .3 The correct fraction after applying the area ratio AG 18.5 **AM2** .1 Correct length ratio .2 Correctly dividing areas .3 Correctly show that area ratio is the square of length ratio AG 18.5	**AM1** .1 $\frac{37.6}{4.7}$ or 8 or $\frac{1}{8}$ OE .2 $(\frac{1}{8^2} =)\frac{1}{64}$ OE or $(8^2 =)64$ OE ACCEPT $(\frac{37.6}{4.7})^2$ .3 $\frac{1184}{64}(=18.5)$ or $\frac{37}{2}$ OE ACCEPT $64 \times 18.5 = 1184$ .3 ACCEPT $\frac{1184}{(\frac{37.6}{4.7})^2}$ **AM2** .1 $\frac{37.6}{4.7}$ or 8 or $\frac{1}{8}$ OE .2 $(\frac{1184}{18.5} =)64$ or $(\frac{18.5}{1184} =)\frac{1}{64}$ OE ACCEPT $\sqrt{\frac{1184}{18.5}} = 8$ .3 $64 = 8^2$ or $\frac{1}{64} = (\frac{1}{8})^2$ or 64 is square of 8 WTTE .3 ACCEPT ratio of area is the square of ratio of side or length ratio is the square root of area ratio WTTE .3 DO NOT ACCEPT 64 is a multiple of 8	**3**

	c	**AM1 (using equations)** .1 Correctly write the second equation .2 Correct step towards solving the correct equations .3 Correctly solve their equations for one unknown x OR y .4 Correctly write their corresponding value of the other unknown satisfying one of their equations .5 Correctly identify x=24 and y=6 **AM2 (using numbers)** .1 Correctly calculate their area using their numbers of small and big triangles .2 Correctly calculate the area using 24 small triangles and 6 big triangles .3 Correctly calculate the area of painting left .4 Seeing their value of x is 4 times their value of y .5 Correctly identify x=24 and y=6	**AM1 (using equations) Note: only .3 and .4 are using their** .1 $2x+5y=80$ ACCEPT using inequality .2 correct substitution: $2x+5\times\frac{x}{4}=80$ or $2\times4y+5y=80$ OR correct coefficients for elimination. Example: 2x + 5y = 80 and 2x – 8y = 0 or 8x + 20y = 320 and –5x + 20y =0 .2 DO NOT ACCEPT working with their equations from .1 .3 (x =) their $\frac{320}{13}$ or 24.61(...) OE OR (y =) their $\frac{80}{13}$ or 6.15(…) OE .4 (x =)their $\frac{320}{13}$ or 24.61(...) OE OR (y =) their $\frac{80}{13}$ or 6.15(…) OE .5 x = 24 and y = 6 or 24 small (triangles) and 6 big (triangles) **AM2 (using numbers) Note: Only .1 and .4 are using their** .1 $(2\times\text{their}24+5\times\text{their}6=)$ their78 .2 $(2\times24+5\times6=)=78$ .3 (80 – 78=) 2 (cm^2) .4 their24 is 4 times their6 .5 x = 24 and y = 6 or 24 small (triangles) and 6 big (triangles)	**5**

Q7		Answers	Notes	Total
	a	.1 Correctly substitute into Arithmetic Progression .2 The correct common difference	.1 $3.5 = 1.5 + 5d$ or $\frac{(3.5-1.5)}{5}$ OE .2 0.4 OE	**2**
	b	Correctly substitute their 0.4 AND 1.5 into the correct arithmetic sequence formula	(H_n =) 1.5 + their0.4(n–1) OE ACCEPT seeing u_1 + their0.4(n–1) if u_1=1.5 is used in part c)	**1**
	c	.1 Correctly substitute n = 12 in their H_n .2 Their correct answer	.1 (H_5 =) 1.5 + their0.4(12 –1) OE .2 their 5.9 (m) .2 ACCEPT only if their 5.9 is in the range]3.5 , 10]	**2**
	d	**AM1 (solving for x)** .1 Correctly set an equation in terms of x .2 Correctly rearrange the equation .3 The correct value for x before rounding down x=5 AG	**AM1 (solving for x)** .1 $3.5x + 1.5(x–1) + 2 \times 2 = 30$ OE ACCEPT using inequality .2 $5x = 27.5$ ACCEPT $5x + 2.5=30$ ACCEPT using inequality .3 ($x = \frac{27.5}{5}$ =)5.5	**3**

		AM2 (using x=5) .1 Correctly set calculations for width .2 Correctly calculate one of : → width of sections and gaps →total width excluding gaps →the remaining distance .3 Correct argument that x = 5 is the maximum possible in the width of 30	**AM2 (using x=5)** .1 Two from → 5×3.5 OE → 4×1.5 OE → 2×2 OE or $30-2\times 2$ OE .2 One of the following is seen → $(5\times 3.5+4\times 1.5+2\times 2=)27.5$ ACCEPT width of sections and in-between gaps $(5\times 3.5+4\times 1.5=)23.5$ → $(30-4\times 1.5-2\times 2=)20$ → $(30-5\times 3.5-4\times 1.5-2\times 2=)2.5$ .3 A corresponding argument from: → $\frac{27.5}{5}=5.5$ or making calculations with x=6 and showing that total 32.5 is more than 30 → $\frac{20}{3.5}=5.7(1...)$ → Recognise 2.5 remaining WTTE DO NOT ACCEPT $\frac{30}{6}$ =5	

	e	.1 Two correct from: x = 5.5 , y = 12.25, 6xy = 348 OE , Region ACCEPT x = 5 , y = 12 .2 A third correct from: x = 5.5 , y = 12.25, 6xy = 348 OE , Region ACCEPT x=5 , y=12 .3 A fourth correct from: x = 5.5 , y= 12.25, 6xy = 348 OE , Region ACCEPT x = 5 , y = 12 DO NOT ACCEPT inequalities Ex: x < 5.5 and y < 12.25 or x <= 5.5 and y <= 12.25 DO NOT ACCEPT numbers not simplified Ex: $y = \frac{6-1.1}{0.4}$	 	**3**

	f	See table below	**10**

7f	**(1 mark)**	**(2 marks)**	**(3 marks)**	**(4 marks)**
Factors (F)	**Two** factors seen in factors box from: - number of seats in a row or in a section, number of sections, or width of section(s) - number of tiers or height - <u>total</u> number of seats or capacity of theatre - width of theatre or space available - gaps that must be left (either in-between or at the ends) ACCEPT using values for any of the above ACCEPT WTTE DO NOT ACCEPT only 'number of seats' as a factor	**Three** factors seen in factors box from: - number of seats in a row or in a section, number of sections, or width of section(s) - number of tiers or height - <u>total</u> number of seats or capacity of theatre - width of theatre or space available - gaps that must be left (either in-between or at the ends) ACCEPT using values for any of the above ACCEPT WTTE DO NOT ACCEPT only 'number of seats' as a factor		

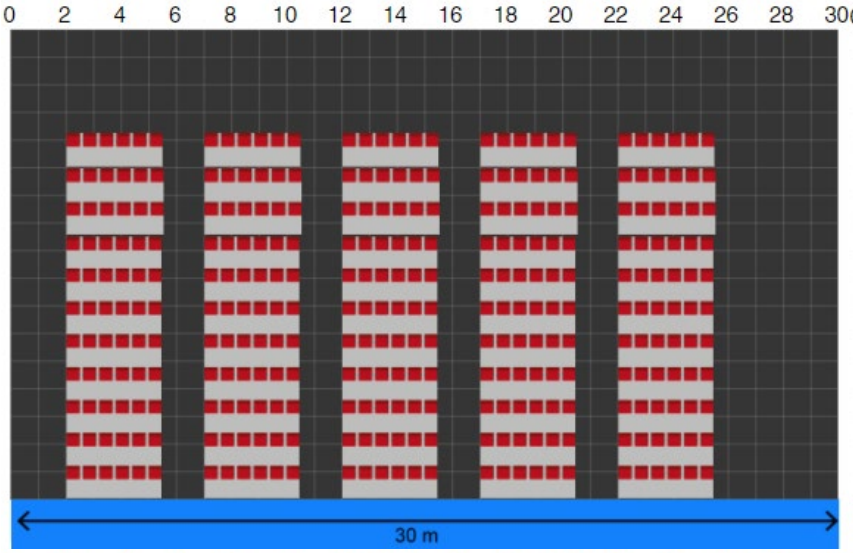
Cal (C)	**Correct calculations for their number of seats in a row or in a block** Total seats per row: 5 × 6 or 30 ACCEPT 348/12 = 29 OE **OR** Total seats in one of their blocks Ex: 8 × 6 or 48 12 × 6 or 72 **OR** Number of sections of seats: 348/6=58	**Correct calculations related to the total number of seats in the range [120,420]** Total number of seats 30 multiplied by their number of tiers: Example: 30 × 4=120 **OR** Number of tiers: Their total number of seats divided by 30 Ex: 348/30=11.6 **OR** Number of blocks of seats: Their total number of seats divided by 6 times their number of tiers Ex: 348/78 (78=6 × 13) ACCEPT correct combinations using blocks for a total in the range [120,420] Ex: 5 × 24 = 120 ACCEPT listing number of seats per block for a total in the range [120,420] Ex: 48,48,48,48,24,24,24,24 DO NOT ACCEPT 29 × 12=348	**Correct calculations for total number of seats in the range [330,360]** **EITHER** 11 × 30 = 330 **OR** 12 × 30 = 360 ACCEPT if they make further step and reach total number of seats in the range [330,360] Ex: 12 × 30 – 10 = 350 ACCEPT correct combinations using blocks for a total of 330 or 360 66 × 5=330 or 72 × 5=360 OE ACCEPT listing number of seats per block only if total is 348 Ex: 48,48,48,48,48,24,24,24,24,12 ACCEPT if they make further step and reach total number of seats in the range [330,360] Ex: 12 × 30 – 10 = 350 OE DO NOT ACCEPT 29 × 12=348	**Correct calculations for a total number of 348 seats** **EITHER** 11 × 30 = 330 then 330+3 × 6=348 **OR** 12 × 30 = 360 then 360 – 2 × 6 = 348 **OR** ACCEPT correct combinations using blocks for a total of 348 Ex: 72 × 3 + 66 × 2 = 348 OE or 72 × 4 + 60 = 348 OE or 48 × 5 + 24 × 4 + 12 = 348 OE DO NOT ACCEPT 29 × 12=348

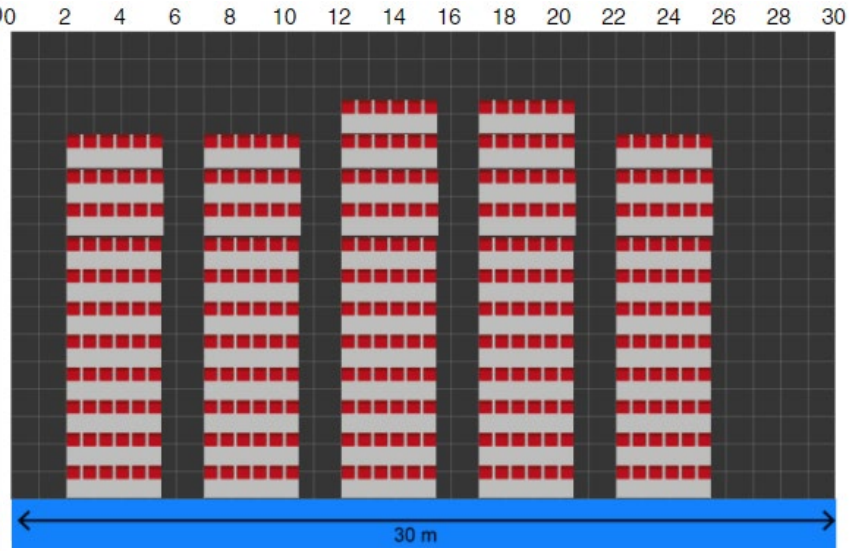
Justify (J)	**Weak justification** **Awareness of effect of constraints** I made the best use (or didn't make the best use) of space within the constraint(s) WTTE ACCEPT for the constraints if they list at least one constraint DO NOT ACCEPT if C0 and D0 are awarded	**Good justification** I made the best use (or didn't make the best use) of space within the constraint(s) WTTE ACCEPT for the constraints if they list at least one constraint **AND** I have blocks of different sizes that do not exceed 12 tiers WTTE (seen on canvas or in calculations) DO NOT ACCEPT if C0 and D0 are awarded		
Design (D)	**Two from:** Gaps between sections ≥ 1.5 Gaps left and right ≥ 2 $330 \leq$ Total number of seats ≤ 348 Tiers ≤ 12 ACCEPT number of seats seen in response box different from number on canvas ACCEPT error in the gaps up to 0.25m DO NOT ACCEPT if their total number of seats on canvas is less than 120	**The four of:** Gaps between sections ≥ 1.5 Gaps left and right ≥ 2 $330 \leq$ Total number of seats ≤ 348 Tiers ≤ 12 ACCEPT number of seats seen in response box different from number on canvas A CCEPT error in the gaps up to 0.25m		

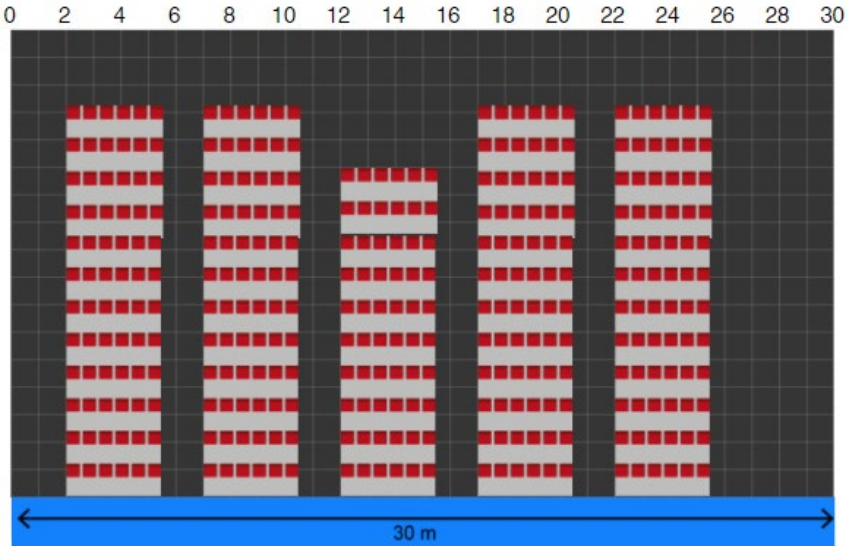
For examples of marks for the design (D) scroll down

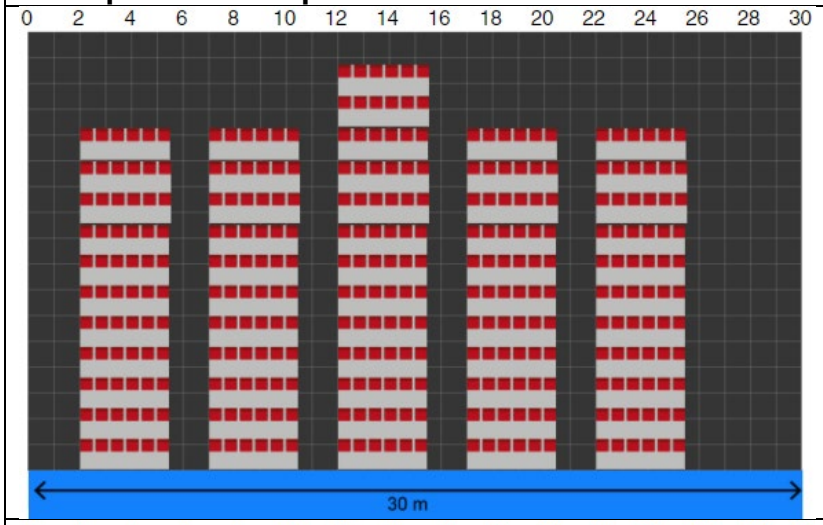
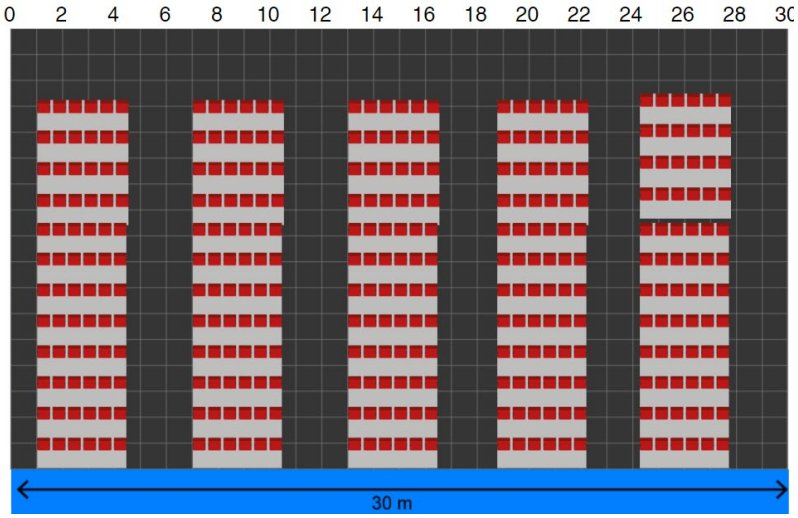
Accepted for D2

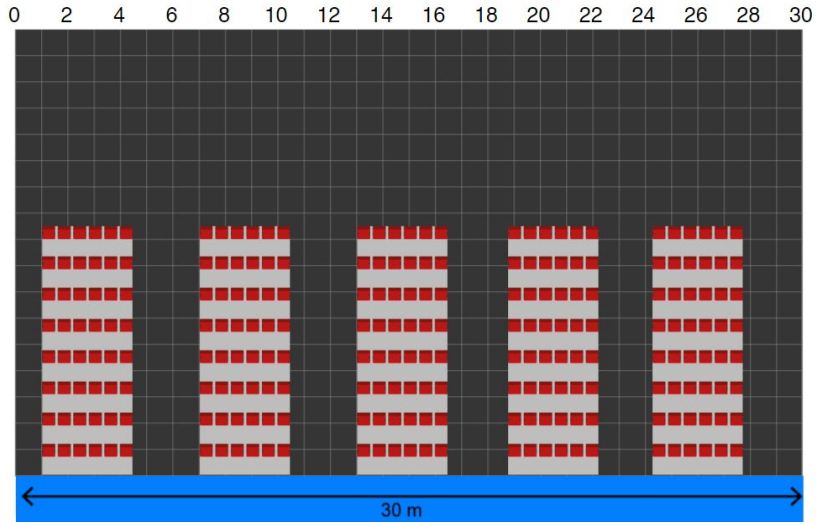
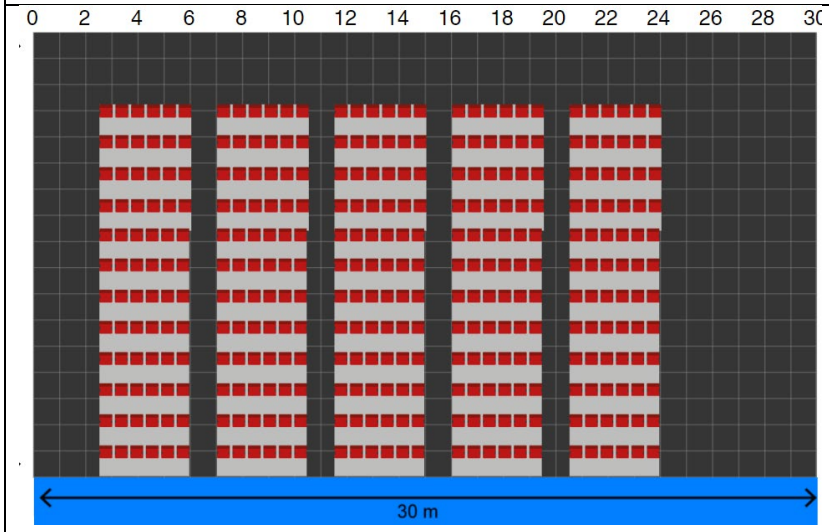
Gaps between sections ≥ 1.5 AND Gaps left and right ≥ 2 AND $330 \leq$ Total number of seats ≤ 348 AND tiers ≤ 12

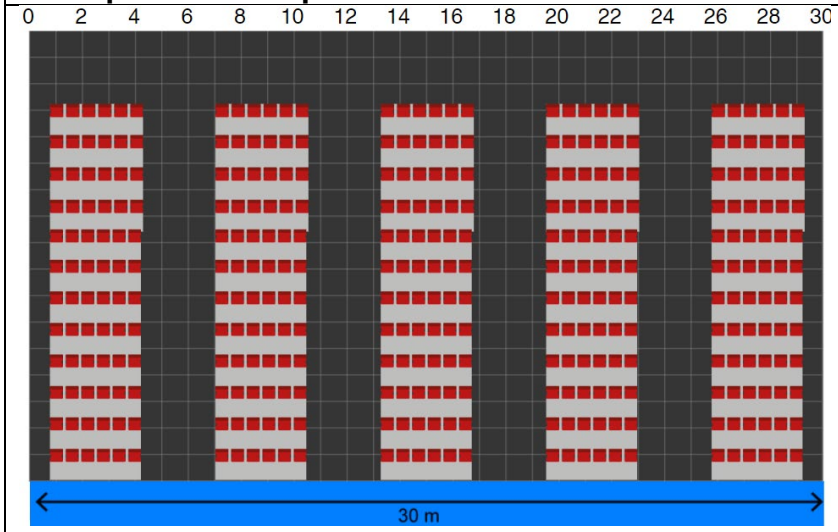
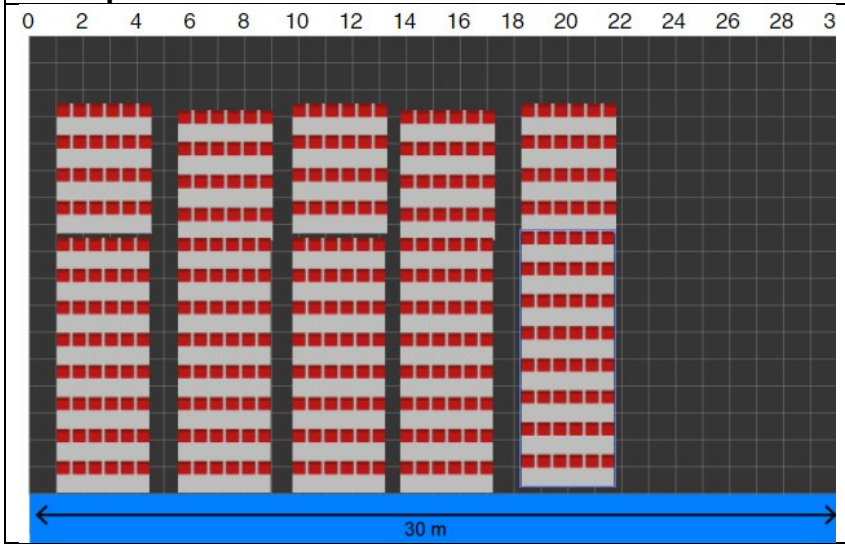


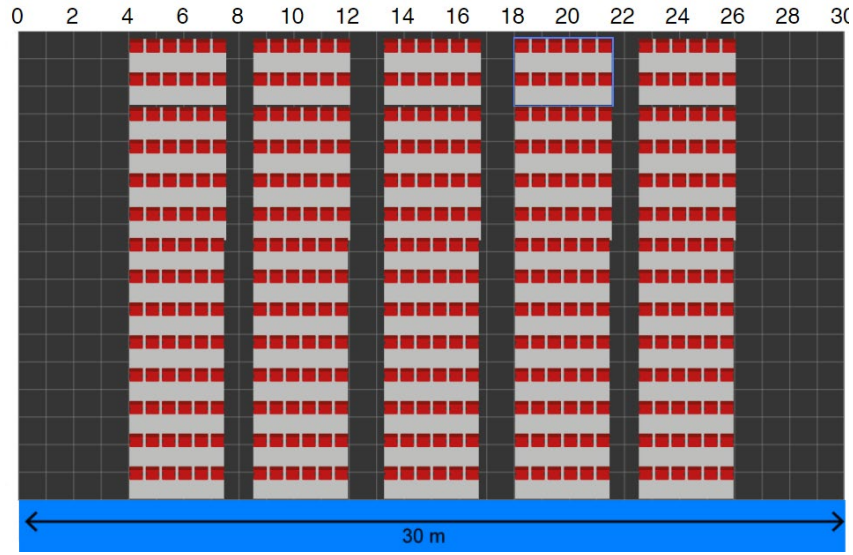
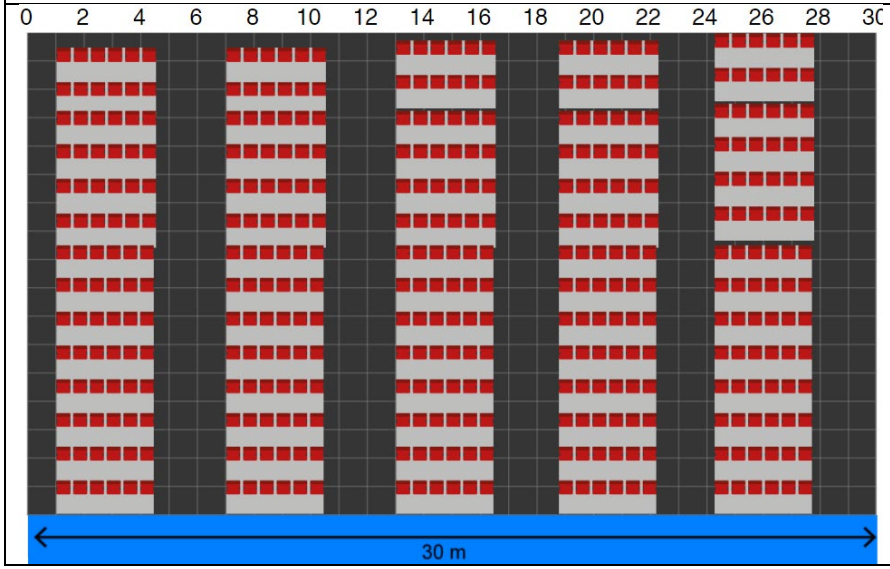




Examples for accepted D1	Reason
	Gaps between sections ≥ 1.5 Gaps left and right ≥ 2 $330 \leq$ Total number of seats ≤ 348
	Gaps between sections ≥ 1.5 tiers ≤ 12

Examples for accepted D1	Reason
	Gaps between sections ≥ 1.5 tiers ≤ 12
	Gaps left and right ≥ 2 tiers ≤ 12

Examples for accepted D1	Reason
	Gaps between sections ≥ 1.5 tiers ≤ 12
Examples for D0	**Reason**
	Only tiers ≤ 12

	Only Gaps left and right ≥ 2
	Only Gaps between sections ≥ 1.5 Note that the gap on the right is >2 but the gap on the left no. So not acceped

Answers			Notes	Total
8	**a**	.1 Correctly describe one pattern in words .2 Correctly describe a second pattern in words	ACCEPT complete terminology only, for example (below are four different descriptions) (*T*) goes up by 4, increases by 4, moves up by 4, adds 4 They are odd numbers Linear with difference 4, arithmetic with difference 4, Constant difference 4 Second difference is zero DO NOT ACCEPT incomplete terminology, for example: Arithmetic, linear, increasing by a constant, constant difference, **the** odd numbers DO NOT ACCEPT the rule in words, for example: 4 times n then subtract 3 The difference between 4*n* and 3 DO NOT ACCEPT *n* goes up by 1 It is increasing general rules in terms of *n*, example: $T = 4n - 3$ More than two different patterns, all correct award **(2 marks)** Ex: adds 4 and Second difference is zero and it is 4 times *n* minus 3 More than two different patterns, with any incorrect award **(1 mark)** Ex: adds 4 and Second difference is zero and it is 4 times *n*	**2**

<table>
<tr>
<td></td>
<td>b</td>
<td>·1 The correct general rule
·2 The correct simplified general rule with correct notation</td>
<td>·1 $4n-3$ or $T=4*n-3$ or $u_n=4n-3$ or $t=4n-3$ or $T=2n+2n-3$ or $T=4x-3$
·2 $T=4n-3$ or $T_n=4n-3$

DO NOT ACCEPT description in words</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>·1 Correctly substitute n ≥ 5 into their general rule
·2 Correctly calculate their value of T after substituting n ≥ 5
·3 Recognize that their result is the same as when continuing the correct pattern. See table below
<table>
<tr><th>Stage
(n)</th><th>Number of triangles
(T)</th></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>2</td><td>5</td></tr>
<tr><td>3</td><td>9</td></tr>
<tr><td>4</td><td>13</td></tr>
<tr><td>5</td><td>17</td></tr>
<tr><td>6</td><td>21</td></tr>
</table>
</td>
<td>·1 Ex: 4 x 5 - 3
·2 Ex: 17 (for the n = 5)
·3 Same as value I predicted in table (and we find the candidate has 17 in the table for n = 5) OR same as when we continue the pattern and explains how 17 is obtained from pattern of adding 4 to 13

·3 ACCEPT seeing the 17 in the table and seeing their calculated T = 17 when n = 5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>AM1
·1 Correctly substitute into trig ratio OR correctly substitute 4 and 8 into Pythagoras OR Correctly recognize ratio of 30-60-90 triangle of 1: $\sqrt{3}$: 2.

·2 Correctly calculate height of triangle h

·3 Correctly substitute values in area of triangle formula OR Correctly calculate area of triangle using decimals AND show that $16\sqrt{3}$ equals the same, using decimals.

$16\sqrt{3}$ AG</td>
<td>AM1
·1 $\sin 60=\frac{h}{8}$ OR $\cos 30=\frac{h}{8}$ OR $h=\sqrt{8^2-4^2}$ ACCEPT $\tan 60=\frac{h}{4}$
Accept not seeing this step.

·2 $\frac{8\sqrt{3}}{2}$ or 6.93 OE ACCEPT $8\sin 60$

·3 $\frac{1}{2}\times 8\times\frac{8\sqrt{3}}{2}$ OE
OR
Both (A=) 27.71(281…) AND $16\sqrt{3}$ =27.71(281…)

AM2 next page</td>
<td>3</td>
</tr>
</table>

		AM2 using $\frac{1}{2}$ab sinC .1 Correctly substitute into the area of triangle formula using sin .2 Correctly calculate area of triangle .3 Show that $16\sqrt{3}$ equals the same $16\sqrt{3}$	**AM2 using $\frac{1}{2}$ab sinC** .1 $(A=)\frac{1}{2}\times 8\times 8\times \sin 60$ .2 (*A*=) 27.71(28…) .3 $16\sqrt{3} = 27.71(28\ldots)$ Showing $16\sqrt{3}$ using other values in the table or using the geometric progression, award 0 marks.	
8	**e**	Scroll down for the marking grid		**23**

Mark	1	2	3	4	5
Predictions (P)	Correctly predict one value for A **OR** two value for L	Correctly predict two values for A **OR** one value for A and two values for L	Correctly predict two values for A **AND** two values for L		

Stage (n)	Side length of outer triangle (L)	Area (A)	Area (A)
1	1	$\frac{\sqrt{3}}{4}$	0.4330127019
2	2	$\sqrt{3}$	1.732050808
3	4	$4\sqrt{3}$	6.92820323
4	8	$16\sqrt{3}$	27.71281292
5	16	$64\sqrt{3}$	110.8512517
6	32	$256\sqrt{3}$	443.4050067
7	64	$1024\sqrt{3}$	1773.620027
8	128	$4096\sqrt{3}$	7094.480108

Description (D)	Correctly describe a pattern in words (for *L or A)* **Examples for *L* :** Value doubles WTTE The difference doubles Increasing by multiplying by 2 All even except 1 It is exponential or geometric Add 1 then add 2 then add 4,…etc OE DO NOT ACCEPT L is increasing *n* goes up by 1 **Examples for *A* :** Value quadruples WTTE The difference quadruples It is exponential or geometric All multiples of $\sqrt{3}$ DO NOT ACCEPT A is increasing *n* goes up by 1 $\sqrt{3}$ is always there Length squared times $\sqrt{3}$ There is a common ratio **OR** Valid attempt to write down general rule for *L* in terms of n Ex.: $L = 2^n$ DO NOT ACCEPT *L*=2n Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words for *L* and for A See patterns in D1 **OR** Correctly describe a pattern in words (for *L* or *A*) and valid attempt to write down general rule for *L* in terms of *n* Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words for *L* and *A* and valid attempt to write down general rule for *L* in terms of *n* **OR** Correctly write down the general rule for *L* in terms of *n* $L = 2^{n-1}$ **OR** Valid attempt to write down general rule for *A* in terms of *n* Examples: seeing in their rule 4^n added or multiplied by something $4^n \times \sqrt{3}$ $A = \frac{1}{2} \times 2^n \times 2^n \times \frac{\sqrt{3}}{2}$ $A = \sqrt{3}L$ $A = u_1 \times 4^{n-1}$ Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words (for *L* or *A*) and correctly write down the general rule for *L* **OR** Correctly describe a pattern in words (for *L* or *A*) and valid attempt to write down the general rule for *A* in terms of *n* **OR** Correctly write down the general rule for *A* in terms of *n* $A = 2^{2n-4}\sqrt{3}$ or $A = \frac{4^n}{16}\sqrt{3}$ or $A = 4^{n-1}\frac{\sqrt{3}}{4}$ or $A = 4^{(n-2)}\sqrt{3}$ Ignore additional incorrect patterns (for Notation see N)	Correctly describe a pattern in words for *L* and for *A* **AND** Correctly write down the general rule for *A* in terms of *n* Ignore additional incorrect patterns (for Notation see N)

Testing (T)	Attempt to test their general rule for A using $n \leq 4$ Correctly substitute in their general rule for A value of $n \leq 4$ **OR** Correctly test their general rule for L or described pattern or recursive rule **OR** Correctly test their rule for A or described pattern or recursive rule ACCEPT testing their general rule for A in terms of L	Correctly test their general rule for A only in terms of n using $n \leq 4$ Ex: Correctly calculate their value for A in their general rule using $n \leq 4$ **AND** Recognize that their correctly calculated value for A is the same as the given value. ACCEPT seeing their correctly calculated value for A and the given value in the table being equal			
Verifying (V)	Attempt to verify their general rule for A using $n \geq 5$ Ex: correctly substitute in their general rule value of $n \geq 5$ **OR** Correctly verify their described pattern or their rule (e.g. recursive rule) ACCEPT verifying their rule for A in terms of L	Correctly calculate their value for A in their general rule only in terms of n using their $n \geq 5$	Correctly calculate their value for A in their general rule only in terms of n using $n \geq 5$ **AND** Recognize that their correctly calculated value for A is the same as their predicted value obtained by continuing the pattern ACCEPT seeing their correctly calculated value for A and their predicted value in the table being equal		

Justify/proof (J)	Attempt to justify a correct described pattern or their general rule Substitute at least two other values of n in A and say they are the same or the rule works OR Seeing $A = 0.5 \times L \times \text{h}$ OE DO NOT ACCEPT $A = 0.5 \times \text{b} \times \text{h}$ OR Recognize it is geometric progression and define first term $\frac{\sqrt{3}}{4}$ or ratio 4, WTTE DO NOT ACCEPT if D1 not achieved	Correctly justify the general rule for A in relation to geometry in terms of L or height of triangle (h) $\text{A} = \frac{1}{2}L \times L \times \frac{\sqrt{3}}{2}$ or $\text{A} = 0.5 \times L \times L \times \sin 60$ OE or $A = 0.5 \times 2^{n-1} \times \text{h}$ OR Recognize it is geometric progression and define first term $\frac{\sqrt{3}}{4}$ and ratio 4, WTTE DO NOT ACCEPT if D3 not achieved	Attempt to justify the general rule for A in relation to geometry in terms of n Examples using area of triangle but including errors : $\frac{2^{n-1} \times 2^{n-1}\sqrt{3}}{2}$ $\frac{2^{n-2} \times 2^{n-2}\sqrt{3}}{2}$ $\frac{2^{n} \times 2^{n}\sqrt{3}}{2}$ ACCEPT seeing the justification inside their work and not separate at the end DO NOT ACCEPT if D3 not achieved	Correctly justify the correct general rule for A geometrically in terms of n Using the area of a triangle $\text{A} = \frac{B \times h}{2}$ or $\frac{a \times b \times \sin C}{2}$ $\frac{2^{n-1} \times 2^{n-2}\sqrt{3}}{2}$ or $\frac{2^{n-1} \times 2^{n-1} \times \frac{\sqrt{3}}{2}}{2}$ ACCEPT seeing the justification inside their work and not separate at the end DO NOT ACCEPT if D4 not achieved	

Communication criteria

Mark	1	2	3
Notation and terminology (N)	Correct notation of their general rule **OR** Correct terminology describing a pattern DO NOT ACCEPT if they don't have any rules and they don't describe any patterns correct	Correct notation of the general rule for *L* or *A* **OR** The notation of the general rule for *L* or *A* includes errors **AND** Correct terminology describing a pattern in words DO NOT ACCEPT if they don't have the general rule For notation of the general rule for *L*, $L = 2^{n-1}$ ACCEPT using *Un* instead of L only if they mention that $L = U_n$ ACCEPT non simplified rules ex: $L = \frac{2^n}{2}$ OE DO NOT ACCEPT Using * for multiplication Using / for division Using ^ for power Using x instead of *n* "the rule for *L* is:" instead of "*L*="	Correct notation of the general rule for *A* **AND** Correct terminology describing pattern in words for *A* DO NOT ACCEPT if they don't have the general rule for *A* For notation of the general rule for *A* $A = 4^{(n-2)}\sqrt{3}$ or $A = 4^{(n-2)} \times \sqrt{3}$ ACCEPT using *Un* instead of A only if they mention that $A = U_n$ ACCEPT non simplified rules ex: $A = \frac{1}{2} \times 2^{2n-2} \times \frac{\sqrt{3}}{2}$ or $A = 4^{n-1}\frac{\sqrt{3}}{4}$ OE DO NOT ACCEPT The Using * for multiplication Using / for division Using ^ for power Using x instead of *n* "the rule for *A* is:" instead of "*A*="

Continued on next page

Mark	1	2	3
Communication (L) Organisation and coherence Can be awarded even if there are errors in their descriptions and working. **Different items can be considered seen (or identified for coherence) if they include errors but not if awarded 0 marks**	**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 · verify their general rule or rule or recursive rule or pattern · justify their general rule or rule or recursive rule or pattern	**At least four** of the following items are seen: · describe a pattern in words (for *L* or *A*) · write a general rule (for *L* or *A*) · test their general rule (for *L* or *A*) · verify their general rule (for *L* or *A*) · justify their general rule (for *L* or *A*) **AND** For coherence, they identify the processes correctly. **At least one** from the following: · test · verify · justify 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:** they say “justify” or "my rule works because" WTTE and their justification is seen → **For justify:** they substitute at least two values of *n* **and** say “the rule justified” or “it works” WTTE → **For justify:** They justify the general rule for *A* geometrically	DO NOT ACCEPT if D4 not awarded **At least four** of the following items are seen: · describe a pattern in words · write the general rule for *A* · test the general rule for *A* · verify the general rule for *A* · justify the general rule for *A* **AND** For coherence, they identify the processes correctly. **At least two** from the following: · test · verify · justify 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:** they say “justify” or "my rule works because" WTTE and their justification is seen → **For justify:** they substitute at least two values of *n* **and** say “the rule justified” or “it works” WTTE → **For justify:** They justify the general rule for *A* geometrically

Extract from the subject report: May 2022

Mathematics

Use of technology

The examination uses an on-screen calculator from desmos https://www.desmos.com/testing/ibmyp/scientific. The calculator display could be copied into the response box. The calculator display was accepted as evidence for candidates' working whenever questions used the command terms "Find" and "Calculate". It is important to note that the calculator display is captured as an image of the calculator screen therefore pressing backspace will delete the whole image. However, by making use of the digital environment candidates can use "ctrl/cmd z" to undo their last action or simply re-paste the calculator screen.

Throughout the examination, use of the WIRIS equation editor was available. In many questions, it was possible to answer algebraic questions without using the equation editor and most candidates did that. Several technology tools were available for students in multiple parts when needed to provide students with sense of ownership and to better present the problems.

In question 7, a short presentation video with relevant context information was available in order to engage the candidates in the problem and to be of help for candidates with different learning styles.

Dragging tool was available in questions 1, 4, and 7, in the mathematics examination and 4 and 7 in the extended mathematics examination. Drawing tools were available in other. The stage controller was available in the simulations provided for questions 6 and 8. In the investigation, question 8, the stage controller helped the students visualise the problem while still leaving the task open-ended. Candidates could select and apply their own problem-solving techniques including, for example, try a simpler case, use a table, work systematically, test, verify and justify.

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Throughout the examination, use of the WIRIS equation editor was available. In many questions, it was possible to answer algebraic questions without using the equation editor and most candidates did that. Several technology tools were available for students in multiple parts when needed to provide students with sense of ownership and to better present the problems.

In question 7, a short presentation video with relevant context information was available in order to engage the candidates in the problem and to be of help for candidates with different learning styles.

Dragging tool was available in questions 1, 4, and 7, in the mathematics examination and 4 and 7 in the extended mathematics examination. Drawing tools were available in other. The stage controller was available in the simulations provided for questions 6 and 8. In the investigation, question 8, the stage controller helped the students visualise the problem while still leaving the task open-ended. Candidates could select and apply their own problem-solving techniques including, for example, try a simpler case, use a table, work systematically, test, verify and justify.

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The areas of the programme and examination which appeared difficult for the candidates

Criterion	Mathematics Standard	Mathematics Extended
Knowing and understanding	Candidates need to be able to demonstrate their understanding of: Similarity of triangles, median and percentiles of continuous data, significance of parameters of a quadratic function, solving simultaneous equations	Candidates need to be able to demonstrate their understanding of: Conditional probabilities, independent events, completing graph with linear and rational functions and linear programming including identifying a region in a graph, representation of exponential functions.
Investigating patterns	Candidates that attempted to apply a learnt algorithm for finding rules struggled with the open-ended investigation i.e. calculating differences.	In the open-ended investigation, finding different patterns appeared challenging, many students wrote the rule in words instead of a pattern related to the values between each term. Candidates only using the formula were not able to justify the general rule geometrically, as requested in the question bullets.
Communicating	Candidates need to demonstrate appropriate use of mathematical language and notation. For example, when a value is required then this means not in the form of an expression in terms of x. In Q8 patterns described in words need to use correct terminology and general rules need to be in appropriate notation. Candidates need to know the command terms and the depth of response required. For example, when a “show that” is required they need to show appropriate working steps to reach the given result. Candidates need to ensure that they provide coherent and concise mathematical lines of reasoning. For example, in the open-ended part of Q7 they had to show the working of their calculations. And in Q8, they needed to show the process of investigation and not just write the general rule. When investigating, few students still faced difficulties communicating coherently, frequently confusing testing with verifying and vice versa. Few candidates still use incorrect notation to express mathematical operations like (*) for multiplication, (/) for division and (^) for exponents. These are unacceptable forms of notation	
Applying mathematics in real-life contexts	Candidates need to watch carefully the short presentation as well the information given in order to transfer their knowledge and skills into the context of the problem. Candidates should avoid referring the factors outside of the context and information given.	

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The areas of the programme and examination in which candidates appeared well prepared

Criterion	**Mathematics Standard** Candidates demonstrated good understanding of:	**Mathematics Extended** Candidates demonstrated good understanding of:
Knowing and understanding	Venn diagram, rounding, Pythagoras, enlargements, and surface area of compound shapes.	Addition rule for probabilities, Pythagoras' theorem, trigonometry in right-angled triangles, surface area, arithmetic and geometric sequences.
Investigating patterns	Candidates were able to correctly predict and continue pattern. They were also able, to a great extent, to describe the pattern in words and as a general rule especially in the guided part.	Candidates were able, to a great extent, to continue patterns and describe the pattern as a general rule, even in the open-ended part.
Communicating	Candidates are improving remarkably in including, in the appropriate places, the calculations supporting their working.	Candidates are improving their communication including when writing algebraic expressions or numerical expression including fractions or exponents.
Applying mathematics in real-life contexts	Candidates were mostly successful when selecting and applying the appropriate mathematical strategies when solving the real-life problems especially in Q6 and Q7.	

The strengths and weaknesses of the candidates in the treatment of individual questions

Mathematics

There was strong evidence suggesting that the examination included a lot of opportunities for candidates to demonstrate their understanding.

Question 1 (Probabilities from Venn diagram, rearranging and solving simple equations, combined and mutually exclusive events)

Candidates were able to complete the Venn diagram in (a). However, in (b) and (c), they mostly gave the answer as an expression in terms of x instead of a value as required in the question. In (d), they mostly had good understanding for the concept of mutually exclusive, but their reasoning needed to be based on values and not expressions including unknown x.

Question 2 (Pythagoras, similarity, and applying similarity on triangles)

In (a) candidates were mostly able to demonstrate understanding for the use of Pythagoras and the correct rounding. In (b), they were not always able to fully justify the similarity. In many cases, there were candidates assuming they are similar and just provided the ratio of sides. Not many realised that only recognising that they were right angled triangles and same angle A was enough. In (c), candidates were mostly able to apply the ratio.

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Question 3 (Median and percentiles of continuous data and understanding of intervals)

In (a), some candidates lacked understanding of the median as a concept, some used the maximum value indicated on the vertical axis (160) instead of the total number (150), and many had lack of accuracy when reading from the graph the median value. In (b) and (c), many candidates were able to write the value of n correctly but some had difficulties in understanding the intervals of continuous data. In (d), many candidates were able to achieve partial marks but only candidates who had good understanding of percentiles were able to achieve highest marks.

Question 4 (Quadratic function and the significance of its parameters)

Candidates performed as expected. They were generally able to demonstrate their conceptual understanding of the significance of the parameters *a* and *c*. They were rarely able to determine the signs of parameter *b* correctly, this part was designed for the highest assessment strands.
.

Question 5 (Bearings, applying Pythagoras in real-life problem, rounding, and trigonometric ratios in real life)

Candidates also performed here as expected. They were often able to demonstrate their understanding of bearings in (a) and transfer their knowledge of Pythagoras in real life in (b). Many had difficulties in selecting the appropriate mathematics in (c), many assumed vertically opposite angles. This part was designed for the highest assessment strands.

Question 6 (Applying mathematics in real life: Surface area of compound shape, enlargements, solving simultaneous equations)

In (a), candidates were mostly able to demonstrate their understanding of area of a plane figure. In (b), candidates were mostly able to determine the length ratio but not many were able to appropriately show how the length ratio was transformed to area ratio then applied on the mask. In (c), many were able to transfer their knowledge and find the number of triangles, but only highest achievers found the numbers by writing simultaneous equations and solving them correctly.

Question 7 (Applying mathematics in real life: forming, rearranging, and solving simple equations)

In (a), candidates were mostly able to transfer their knowledge and successfully calculate the maximum number of tiers using a good variety of methods. In (b), students were mostly able to achieve partial marks when showing that the *x* value is 5 and many of them were able to show it using numbers appropriately and reach highest marks. Only highest achievers were able to use equations to show that *x* is 5. Part (c) was removed as linear programming is not in the standard level of the mathematics skills framework. In (d), many candidates were able to identify relevant factors, but not so many were able to identify three different factors, note the factors were explicitly given in the introductory video. Many candidates showed partial calculations of the number of seats in their design but only highest achievers communicated well the calculations leading to their design. The candidates seemed to enjoy the presentation of design by dragging sections on the canvas and they generally made a suitable design even if not well supported by calculations.

Question 8 (guided and open-ended investigation)

In general, candidates performed well in the scaffolded parts. In (a), they generally described well how stage 2 included 5 triangles. It seems that the stage controller helped candidates a lot in understanding the problem. In (b) they were able to continue the pattern by completing the table. In (c), they were able

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to describe in words one pattern but not all of them recognised another pattern. In (d), they were generally able to describe the pattern as general rule but often not written in the appropriate notation. Many did not write appropriately $T = 4n - 3$ and they used other variables or non-simplified rules. In (e), many candidates confused testing with verifying. In (f), mostly candidates were able to simply show how three times 8 gives 24 and this helped them, as intended, in the understanding of the open-ended part. However, few just continued the pattern as numbers and did not relate the pattern of number to the geometrical context.

In the open-ended part (f):

Candidates were mostly successful in making predictions and continuing the pattern as well as describing the pattern in words. However, many need to give more care and use appropriate terminology when describing the pattern in words.

Candidates who followed the investigation process, and tried to determine the general rule based on the pattern continuation and the description of the pattern in words, were mostly able to write the general rule for length (L) and consequently perimeter (P) with a justification related to geometry. These were able to achieve highest marks.

Many candidates used an automatic process, unrelated to the context of the problem or the pattern described in words, and just calculated first difference then attempted generalise a linear rule. These candidates were only able to successfully test or verify one stage. Candidates who still applied this same automatic process and found quadratic general rules, that satisfied several stages, were able to score higher as they were able to achieve more marks in the description of general rule, testing and verifying.

Many candidates communicated the investigative process well and knew the difference between test and verify. Consequently, they were able to achieve highest marks in communication. However, some candidates still confuse the test and verify or do not mention whether they are testing or verifying when substituting values of n in their rule, this means they do not coherently communicate they process.

Candidates mostly used appropriate notation. However, few were still using (*) for multiplication (/) for division and (^) for exponents, or didn't write in their general rule $P=$, all of which are inappropriate notation. Many candidates used appropriate terminology when describing pattern in words, however, still some used inappropriate terminologies like it is x2.

Extended mathematics

Question 1 (Mean and standard deviation from histogram)

Candidates were able to demonstrate their conceptual understanding of the mean as measure of central tendency and standard deviation as measure of dispersion. Given the nature of a multi-choice question a few candidates appeared to guess without understanding the histogram.

Question 2 (Probabilities)

Candidates were mostly able to apply the correct rules for probabilities in (a), (b) and (c). Where candidates did incorrect working in (a), they mainly identify incorrectly that it was related to the conditional probability. In (b), few candidates were confused between independent events and mutually exclusive events. Most candidates were able to use the addition rule in part (c).

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Question 3 (Pythagoras, similarity, and applying similarity on triangles)

Candidates were mostly able to communicate their understanding of Pythagoras' theorem in part (a). Few of them used correct trigonometry to find the answer. In part (b), they had to show the similarity of two triangles and many candidates only showed partially the similarity. Where identifying a common angle A and that both triangles were right-angled triangles was enough, few candidates only mentioned the right angle or added the fact that they both shared side AC which didn't help for the similarity. Few candidates didn't communicate correctly their used angles or sides and it became impossible for the team to award appropriate marks. In part (c), there were many possible methods to find the length of AB and many candidates found a way to use ratios or correct trigonometry to succeed. However, again, few candidates faced difficulties using correct angles or sides and made mistakes using their ratios or their trigonometric ratios.

Question 4 (Representation of exponential function)

Candidates were sometimes able to demonstrate their understanding of the logic surrounding the representation of the exponential function. Many of them correctly identified the horizontal asymptote but generally faced difficulties understanding the other parameters.

Question 5 (Bearings, sine rule, cosine rule, minimum total distance route)

Candidates were mostly able to demonstrate their understanding of the bearings and the angles. They were generally able to use the cosine rule and appropriate rounding. In part (c) and (d), most of them faced difficulties applying trigonometry in a more complex real-life situation to find the minimum total distance route. They were able to correctly use sine rule or trigonometric ratios, but often had to work with incorrect values. Angles at the centre were often incorrectly assumed to be equal, but they were not. Many candidates had difficulties communicating their work in part (d) where it appeared often less organized.

Question 6 (Applying mathematics in real life: Surface area of compound shape, enlargements, solving simultaneous equations)

Candidates were mostly able to demonstrate their understanding of the surface area in part (a), even with compound shape. In part (b), for most candidates, they were able to find length ratio and showed the correct area ratio. However, few candidates didn't understand ratios and tried to find the area with the values given, but that didn't lead to anything correct. In part (c), candidates were generally able to find a solution and many of them found the correct one. However only few candidates used algebra to solve simultaneous equations.

Question 7 (Applying mathematics in real life: arithmetic sequence, forming, rearranging, and solving simple equations, linear programming)

Candidates were mostly able to demonstrate their understanding of the concepts especially with the arithmetic sequence (a) - (c). In (d), where they were asked to "**show that** the value of x is 5", strong candidates used algebra and easily demonstrated what was asked. Candidates who used a trial and improvement method, faced difficulty to coherently meet the requirements of the command term. In (e), the linear programming appeared to be very challenging for candidates. They had to label equations of lines and identify a region on a graph, but only very few of them succeeded. Many candidates understood what line was related to the constraint, but weren't able to write the equation or chose to write words instead (ex.: constraint #1 instead of $x = 5$).

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In (f), many students were able to identify relevant factors and few of them succeeded to identify three different factors. Calculations for the number of seats were mostly partial as many candidates didn't took into consideration of all constraints. Only few candidates were able to correctly justify the best use of space for their design as many of them only mentioned that it was respecting the constraints without further details. The students seemed to enjoy the presentation of design by dragging sections on the canvas and they generally made a good design even if not well supported by calculations.

Question 8 (guided and open-ended investigation)

Candidates generally did well in this question, especially in finding the general rules both in the guided and open-ended parts.

In (a), most of them described at least one pattern in words. Only the highest achievers succeeded with a second correct pattern. Most candidates were able to find the general rule $T=4n-3$ in (b) as well as successfully verify in (c). A few candidates still try to verify with values already given ($x<5$ in that case), however this year an increasing number of candidates understood that using these values is for testing and not verifying.

In (d), many candidates achieved the "**show that** of the area of the outer triangle in stage 4 is $16\sqrt{3}$" however other used values from the table and continued the pattern. This question was a guided part to help candidates to justify the rule in relation to the triangle.

In (e), the open-ended part, candidates succeeded in continuing the pattern and were able, to a great extent, to describe the pattern as general rule. However, the description of patterns in words was still more difficult. Few candidates did not use correct terminology or tended to describe the general rule in words rather than the patterns observed. .

Investigating a pattern requires a test phase and a verification phase and this year again, more candidates understood the difference between them. However, still a few candidates did not specify what they were doing or only did one of the phases.

This year, investigation process asked for students to justify the rule in relation to the triangles. A lot of candidates didn't justify at all or tried to justify only the coefficients of the rule without relation to the triangles. Bullet points in the question are there to help candidates in their process and it's important to follow them, specifically justifying the general rule geometrically.

Communication of the working is an important part of this task and most candidates wrote good things. Few candidates are still showing unorganized working and unidentified parts which makes the working less clear and less coherent.

The correct notation is very important especially when writing a general rule and again, we saw good improvements from candidates this year. One part still to improve is the fact that each general rule must include an isolated subject and an equality sign ($L = \ldots$ or $A = \ldots$) and not only the expression (for example $T=4n-3$ and not only "the rule is $4n-3$"). Many candidates used the notation $U_n \ldots$ which was incorrect in the context where they were asked for a general rule for A in terms of n.

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Recommendations and guidance for the teaching of future candidates

1. Review different notation, symbols and operations that can be used to write a general rule and emphasise the definition of terms in a formula. Emphasise the importance of correct notation – Further information can be found in the eAssessment section of the subject guide available on the programme resource centre.

2. Practice writing on-screen mathematics using equation editor in the platform in response boxes and tables. Writing correctly indices, surds, logs and brackets should be familiar for candidates during the examination.

3. Familiarization with the on-screen calculator is important: in particular: the new desmos calculator and screen capture function into the response box. In previous years, after reviewing the videos in response to reports of issues with the calculator, it was clear that these individuals were not familiar with the on-screen platform. The videos showed that candidates were trying to enable the calculator by clicking on the icon for screen capture in the response box rather than the main calculator icon in the menu bar at the top of the screen. It is therefore important that invigilators and candidates know their way around the platform.

4. Emphasise the use of correct terminology when describing patterns.

Inappropriate terminology	**Appropriate terminology**
The multiply of the numbers	The product of the numbers
The multiply of 2, or the 2 times table	The multiple of 2
It goes high 2, goes up by 2	It increases by 2
It lowers 2	It decreases by 2
It is x2 every time	It doubles
In 3y the number next to y	The coefficient of y

5. Understanding the command terms often saves time for candidates. The command term of each question is an indicator for the amount of work needed and amount of time required. A ‘write down’ question does not require method and should be straight forward to answer, many candidates spent too much time for ‘write down’ and ‘determine’ questions, which would have affected the time they had available for extended responses later in the examination with more demanding command terms such as ‘evaluate’, ‘find’ and ‘investigate’. For “determine”, it is better to show the working step before the answer as it helps in achieving partial marks in the answer is correct. On the other hand, it is necessary in a “find” and “calculate” question to see all the working. For “show that” questions, candidates must show all stages of working, a pre-rounded value if appropriate, followed by the answer to compare with the value given. Command terms used in the examination are taken from *MYP: From principles into practice* (2014).

6. Candidates need to pay great attention when reading the questions. For example, when the question requires a value then this means a value and not an expression in terms of an unknown.

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When a reading from a graph is required to solve a question, they need to read accurately from the graph and may use the drawing tools when needed.

7. It is expected that candidates understand the MYP assessment objectives. The examination includes applying mathematics in real-life contexts in Task 2 and candidates need to be able to respond to the different strands of criterion D.

   Teachers should emphasise to candidates that they should respond to each of the guidance bullet points as well as using the command term provided.

   The factors relevant to the problem in task 2 are always in the context provided and should be explicitly identified in the appropriate response box.

   When calculations are required in the bullet points, remind candidates to show the calculations and not just write the final answer.

   When questions require interpretation of a real-life situation, remind candidates to always give interpretations in context of the problem, based on information given in the question and justifying their arguments using mathematics. In fact, they should also be advised to avoid justifications not related to mathematics. Justify the degree of accuracy of a solution is a strand in criterion D and will normally also be specifically asked for in the bullet points.

   Justifying the degree of accuracy should begin with mentioning whether the solution is accurate or not and not just mentioning the precision that was used to make the calculations or give the answer. For example, “I gave my answer to one decimal place” is not enough. To justify, it should also continue with a valid reason related to the context of the problem.

8. Similarly, in Task 3, candidates need to be familiar with the strands of criterion B and the process of investigating patterns. Following the process of investigating patterns makes it easier for students to recognise the general rule of the pattern.

   Emphasis has to be made on the entire process of investigating which involves describing the pattern in correct terminology, expressing the pattern as general rule in the appropriate notation, testing the general rule, verifying the general rule, and justifying or proving (when possible) the general rule.

   Many candidates still confuse the testing with verifying. Testing the general rule is by substituting a value, in the range provided, into their rule and comparing this result with the value in the table or similar. Verifying the general rule is by substituting a value, outside the range provided, into their rule and comparing this result by continuing the pattern. And for both, candidates should remember to communicate that the two results are the same. It is important that the candidates know the difference between testing and verifying and not just use as many values as they can. Just using as many values as they can negatively affect the evaluation of their communication level and also makes them lose time unnecessarily.

   Candidates should broaden their techniques for finding and justifying the general rule, using method of differences is very time consuming in an examination situation. The recommended method is to use the context of the investigation and justify the general rule in the context of the investigation

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Communication is also assessed in the open-ended question and candidates are expected to communicate in appropriate notation and terminology their process of investigating the general rule.

Candidates should have enough time to investigate and to write up their results. The open-ended part of question 8 had 23 marks allocated indicating that it is close to one quarter of the exam; candidates should allocate approximately 30 minutes to their response.

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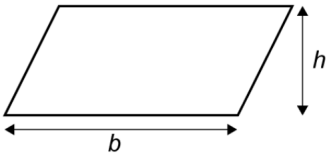
Area
Surface area and volume
Linear functions
Quadratic functions
Pythagoras' Theorem and trigonometric ratios
Statistics and probability

Area

Area of parallelogram

$A = b \times h$, where b is the base, h is the height

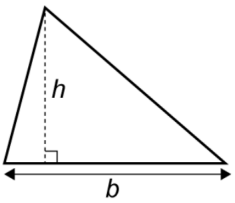
Parallelogram



Area of a triangle

$A = \frac{1}{2}(b \times h)$, where b is the base, h is the height

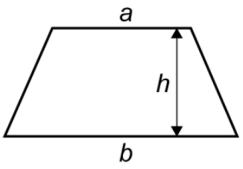
Triangle



Area of a trapezium

$A = \frac{1}{2}(a + b)\,h$, where a and b are the parallel sides, h is the height

Trapezium



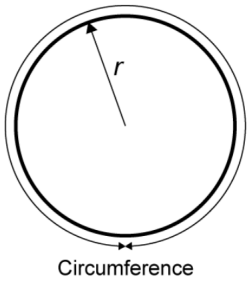
Area of a circle

$A = \pi r^2$, where r is the radius

Circle

Circumference of a circle

$C = 2\pi r$, where r is the radius



Area
Surface area and volume
Linear functions
Quadratic functions
Pythagoras' Theorem and trigonometric ratios
Statistics and probability

Surface area and volume

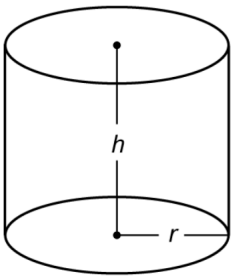
Area of the curved surface of a cylinder

$A = 2\pi rh$, where r is the radius, h is the height

Volume of a cylinder

$V = \pi r^2 h$, where r is the radius, h is the height

Cylinder



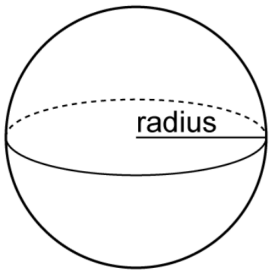
Surface area of a sphere

$A = 4\pi r^2$, where r is the radius

Volume of a sphere

$V = \frac{4}{3}\pi r^3$, where r is the radius

Sphere



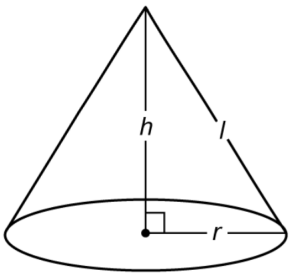
Area of the curved surface of a cone

$A = \pi rl$ where r is the radius, l is the slant height

Volume of a cone

$V = \frac{1}{3}\pi r^2 h$, where r is the radius, h is the vertical height

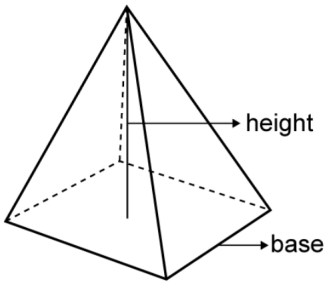
Cone



Volume of a pyramid

$V = \frac{1}{3}Ah$, where A is the area of the base, h is the vertical height

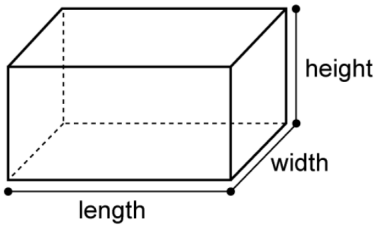
Pyramid



Volume of a cuboid

$V = l \times w \times h$, where l is the length, w is the width, h is the height

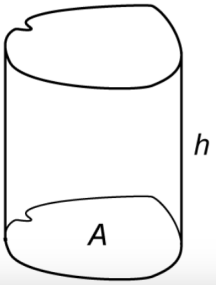
Cuboid



Volume of a prism

$V = Ah$, where A is the area of cross-section, h is the height

Prism



Area
Surface area and volume
Linear functions
Quadratic functions
Pythagoras' Theorem and trigonometric ratios
Statistics and probability

Linear functions

Coordinates of the midpoint of a line segment with endpoints (x_1, y_1) and (x_2, y_2)

$$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

Distance between two points (x_1, y_1) and (x_2, y_2)

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Equation of a straight line

$$y = mx + c; \quad ax + by + d = 0$$

Gradient formula

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Area
Surface area and volume
Linear functions
Quadratic functions
Pythagoras' Theorem and trigonometric ratios
Statistics and probability

Quadratic functions

Axis of symmetry of graph of a quadratic function

$f(x) = ax^2 + bx + c \Rightarrow$ axis of symmetry $x = -\frac{b}{2a}$

Solutions of a quadratic equation

$$ax^2 + bx + c = 0 \Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad a \neq 0$$

Discriminant

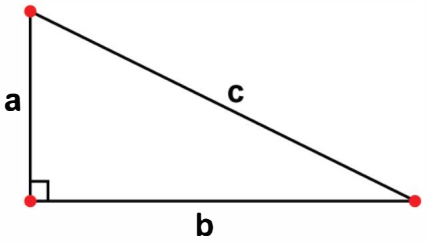
$\Delta = b^2 - 4ac$

Area
Surface area and volume
Linear functions
Quadratic functions
Pythagoras' Theorem and trigonometric ratios
Statistics and probability

Pythagoras' Theorem and trigonometric

Pythagoras' Theorem

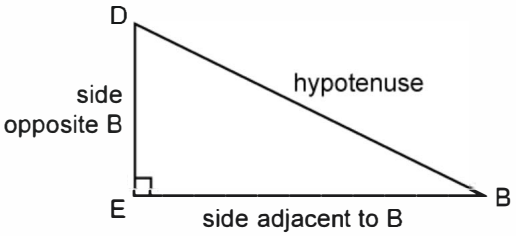
$c^2 = a^2 + b^2$



Trigonometry identity

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

The basic trigonometric ratios



$$\sin B = \frac{\text{opp}}{\text{hyp}}$$

$$\cos B = \frac{\text{adj}}{\text{hyp}}$$

$$\tan B = \frac{\text{opp}}{\text{adj}} = \frac{\sin B}{\cos B}$$

Abbreviations for side lengths:

opp: opposite
adj: adjacent
hyp: hypotenuse

Area
Surface area and volume
Linear functions
Quadratic functions
Pythagoras' Theorem and trigonometric ratios
Statistics and probability

Statistics and probability

Statistics

Arithmetic mean of a set of data

$$\text{Arithmetic mean} = \frac{\text{sum of the values}}{\text{total number of values}}$$

Interquartile range IQR = upper quartile − lower quartile = UQ − LQ = $Q_3 - Q_1$

Probability

Probability of an event *A*

$$P(A) = \frac{\text{number of outcomes in } A}{\text{total number of outcomes}}$$

Mutually exclusive events

$P(A \cap B) = 0$

Complementary events

$P(A') = 1 - P(A)$

Combined events

$P(A \cup B) = P(A) + P(B) - P(A \cap B)$