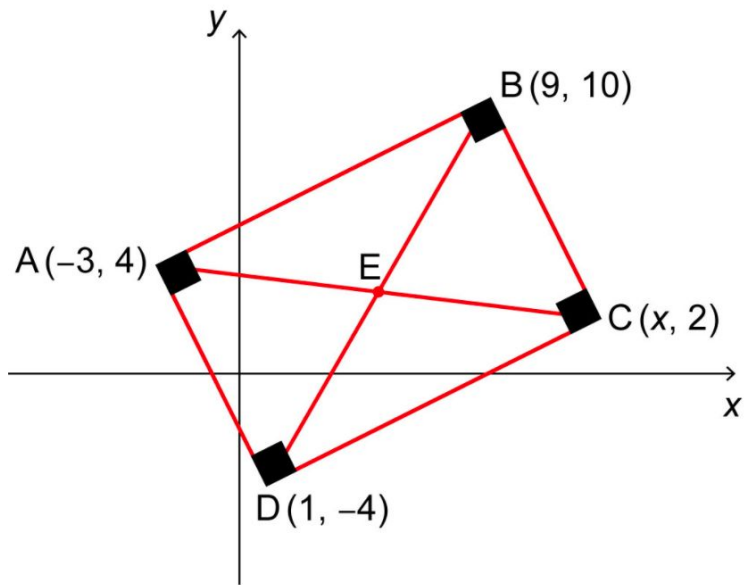


Question 1

ABCD is a rectangle with the given coordinates of vertices.



The diagonals of the rectangle intersect at point E.

Question 1a (4 marks)

Using gradients, **show that** AB is perpendicular to AD.

Question 1b (2 marks)

Determine the x coordinate of point C.

Question 1c (3 marks)

Calculate the length of AB, give your answer in simplest surd form.

Question 1d (2 marks)

Determine the coordinates of point E.

Question 2 (9 marks)




The map below shows cycle paths and visitor sites in a woodland park.

Woodland map








Diagram not to scale

Key:

-  Cycle paths
-  Woodland
-  Lake

Visitor sites

-  Car park
-  Sculpture park
-  Restaurant
-  Lake
-  View point

The length of the cycle path $AB + BE$ is 12 km

The length of the cycle path $AB + BD + DE$ is 19 km

Question 2a (4 marks)

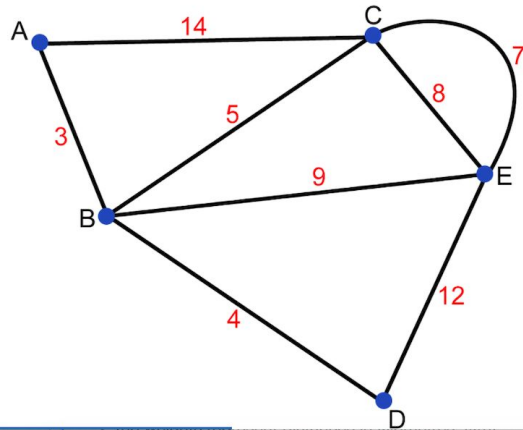
By solving simultaneous equations, **show that** $x = 0.5$ and $y = 3$.

Question 2b (2 marks)

The woodland map can be represented by the network diagram as shown in the simulation.

- the edges represent cycle paths in the woodland
- the weights represent distances in kilometres, (km)
- the vertices/nodes represent visitor sites, for example A is the car park.

The woodland ranger needs to check that all the cycle paths are safe to use. Starting and finishing at the car park A, **determine** the shortest distance the ranger will cycle.



Question 2c (3 marks)

A tourist wants to pass by every visitor site in the woodland using the shortest route. They will start and finish at the car park A.

Calculate the shortest distance and route they should cycle.

Question 3 (6 marks)

Below is a geometric sequence with first term $U_1 = \log 2$ and common ratio r .

$\log 2, \log 4, \log 16, \log 256, \dots$

Question 3a (1 mark)

Using laws of logarithms, **show that** the common ratio r is 2.

Question 3b (3 marks)

Given that

$$\log 1024 + \log 256 - \log 4 = t$$

Using laws of logarithms, **show that**
 t is the 5th term of the sequence.

Question 3c (2 marks)

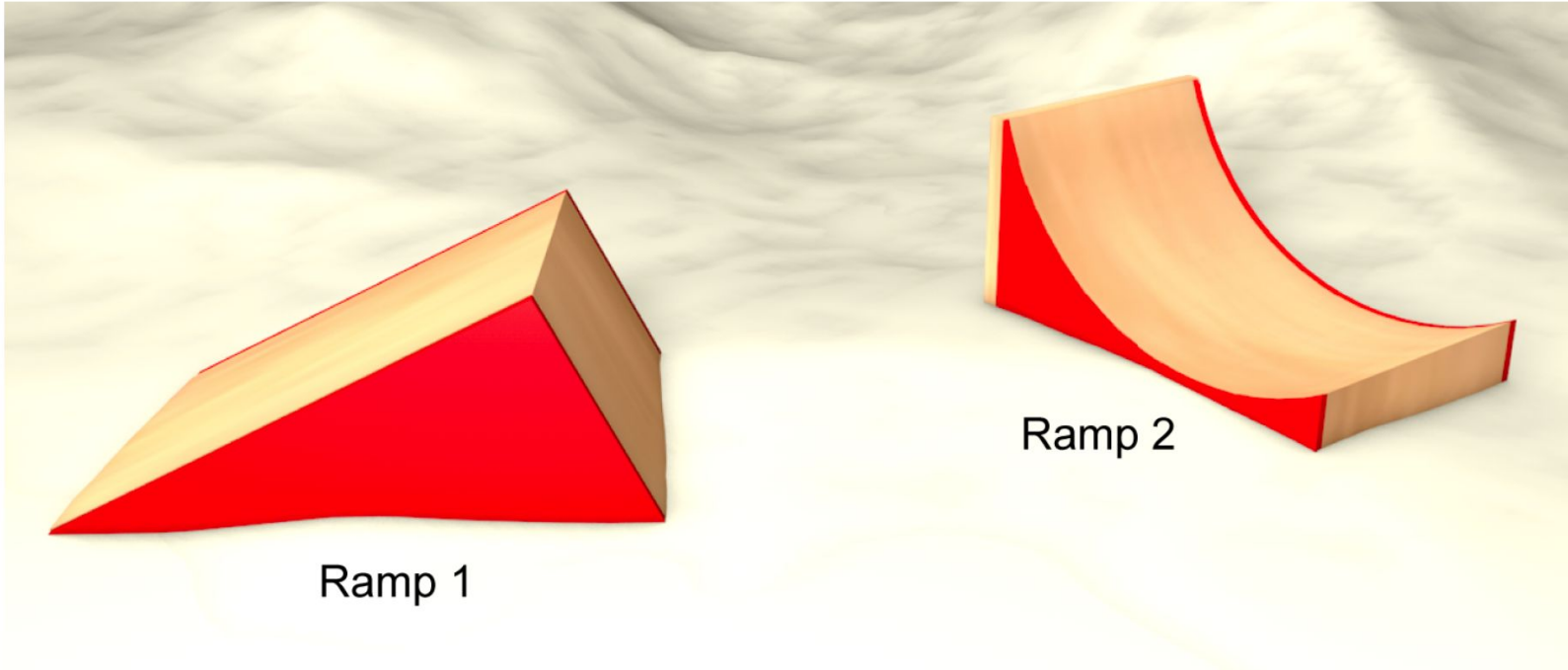
Determine the sum of the first 6 terms.

Give your answer in terms of $\log 2$.

Question 4

An engineer is designing two types of ramps for a skiing event. You will calculate dimensions for the ramps.

Diagram not to scale

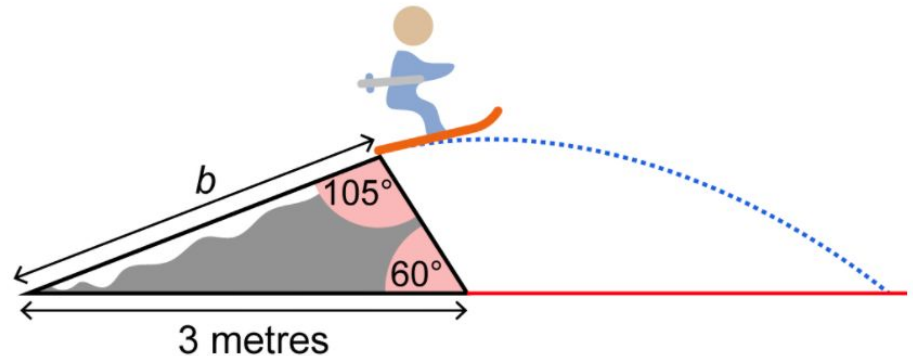


Question 4a (3 marks)

Calculate the length (b). Give your answer correct to three significant figures.

Ramp 1

The cross-section of Ramp 1 can be modelled as a scalene triangle.

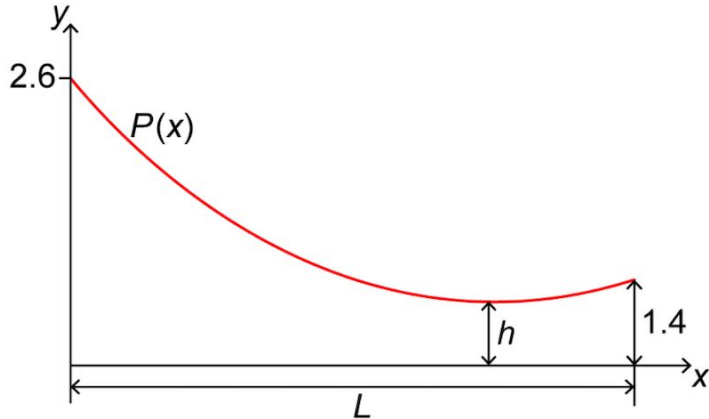


Ramp 2

The cross-section of Ramp 2 is shown in the image. The curved path is modelled as a parabola with equation

$$P(x) = a(x - 2)^2 + 1$$

Where $P(x)$ represents the height of the ramp and x represents the horizontal distance from the start of the ramp. Dimensions in metres.



Question 4b (1 mark)

Write down the minimum height (h) of the ramp.

Question 4c (2 marks)

Show that $a = 0.4$.

Question 4d (4 marks)

Hence, **find** the horizontal length (L) of the ramp.

Question 5:

In this question you will explore relationships between genes and hair colour of people in a community.

Identity and relationships are important aspects of belonging within a community. In this question you will explore how hair colour can be linked to communities and hereditary traits.

It is estimated that around 1–2 % of the world's population have natural red hair.

The map illustrates areas of the world where red hair is located.

From the map you can see that in some parts of the world, red hair is more common.

Research has shown that the likelihood of a person having red hair is attributed to the genes inherited from each parent.

One gene from each parent.

However, there are other factors involved.

If a child inherits two red hair genes, one from each parent, they are likely to have red hair however this is not a certainty.

If a child inherits only one or no red hair genes, they are less likely to have red hair but it is possible.

A research group (A) is exploring relationships between genes and red hair in a community. A random sample of 1500 people from the community are studied.

The probability tree diagram below illustrates the results from the sample group.

Key:

Event G represents people that have two red hair genes

Event G' represents people that do not have two red hair genes

Event C represents people that have red hair

Event C' represents people that do not have red hair

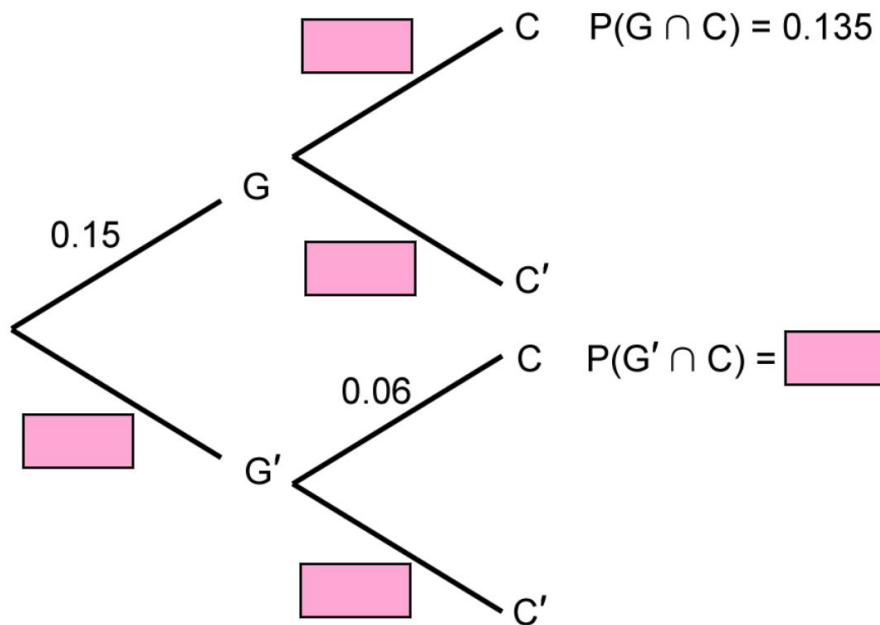
Question 5a (2 marks)

Write down the missing items in the table below.

Probability notation	Description in the context
$P(G \cap C)$	Probability of selecting a person who has two red hair genes and has red hair
$P(G \cap C')$	Probability of selecting a person who has two red hair genes and does not have red hair
$P(\square \cap \square)$	Probability of selecting a person who does not have two red hair genes and has red hair
$P(G' \cap C')$	Probability of selecting a person who <div style="background-color: #f8d7da; height: 20px; width: 100%;"></div>

Question 5b (3 marks)

Determine the missing values in the probability tree diagram below.



Key:

Event G represents people that have two red hair genes

Event G' represents people that do not have two red hair genes

Event C represents people that have red hair

Event C' represents people that do not have red hair

Question 5c (2 marks)

Show that events G and C are not independent.

Question 5d (3 marks)

Given that the community has a population of 15 500, correct to three significant figures.

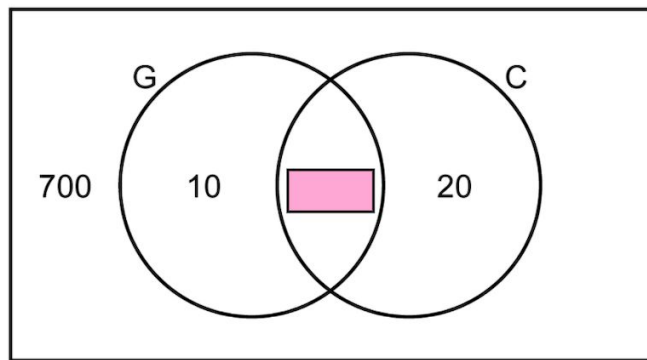
Estimate the lower bound for the number of people that have red hair in this community.

A different research group B conducts the same study with the same community, however they sample 800 people.

The Venn diagram below illustrates the results from research group B.

Question 5e (1 mark)

Write down the missing value in the Venn diagram.



Key:

Event G represents people that have two red hair genes.

Event C represents people that have red hair.

Question 5f (3 marks)

Research group B makes the following conclusion

“Approximately, 1 in N people from this community have red hair.”

Given that N is a whole number, **find** the value of N .

Question 5g (1 mark)

Write down the percentage difference between the probability $P(C)$ of the two research groups.

Question 6 (19 marks)

Buildings designed for apartment living provide homes for many individuals and families within a defined space.

The table below shows information about the number of residents in each age group in a building.

Age group (A) in years	Number of residents
$0 < A \leq 10$	59
$10 < A \leq 20$	72
$20 < A \leq 30$	54
$30 < A \leq 40$	126
$40 < A \leq 50$	15
$50 < A \leq 60$	5
Total Number of residents	331

Question 6a (1 mark)

Write down the modal class of age of residents.

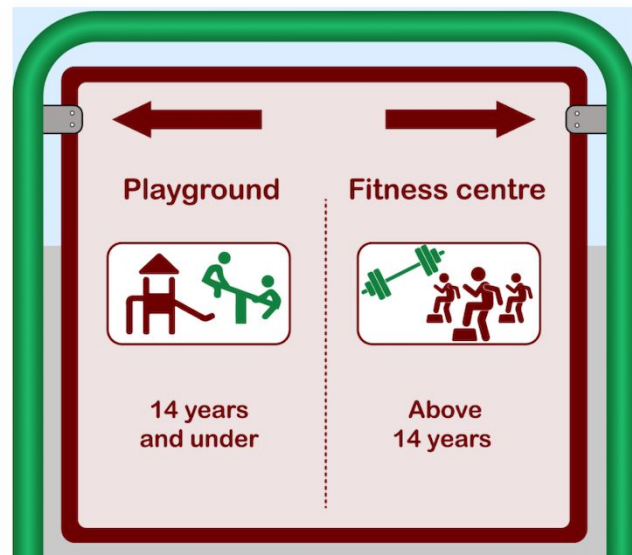
Question 6b (4 marks)

Calculate an estimate for the arithmetic mean age of residents.

Question 6c (2 marks)

The building also provides an opportunity for residents to come together as a community in a recreational area.

The recreational area is divided into a children's playground and a fitness centre with age restrictions as follows.



Show that 115 children are allowed in the playground.

The residents in the age group $10 < A \leq 20$, are in the ratio:

$$\begin{array}{l} 10 < A \leq 14 \quad : \quad 14 < A \leq 20 \\ 7 \quad : \quad 2 \end{array}$$

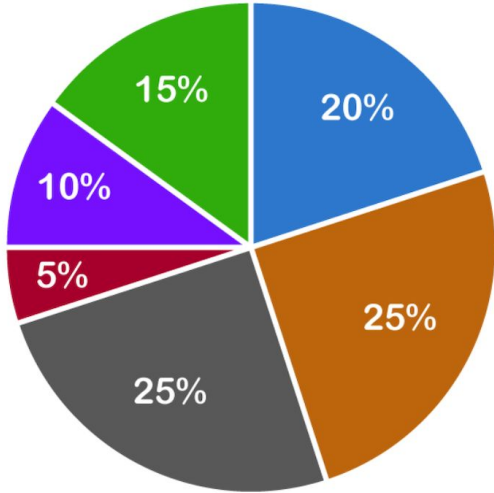
You are responsible for making calculations for the recreational area in order to stay within an allocated budget.

Building maintenance budget



Residents pay an annual fee which provides the budget to pay for maintenance of the building.

The pie chart below shows how the maintenance budget is distributed



Key:

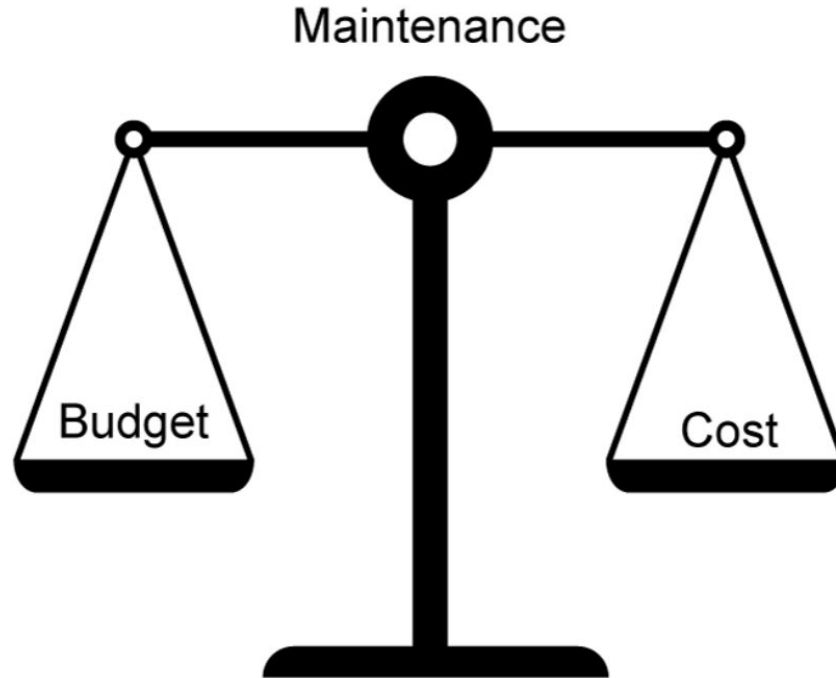
- Recreational area
- Gardening
- Decoration
- Security
- Electricity
- Cleaning

Question 6d (2 marks)

Determine the annual maintenance budget for the recreational area.

Question 6e (10 marks)

The maintenance budget and maintenance cost need to balance for the recreational area.



The monthly maintenance cost of the recreational area is calculated using the information given in the Playground and Fitness tabs below.

Playground

The playground requirements

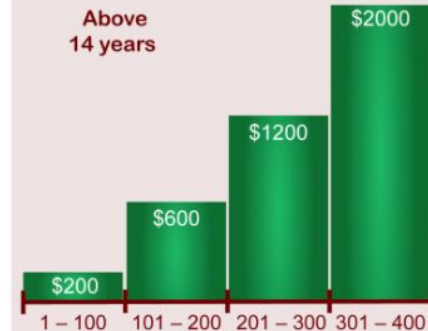
- 15 m² for every 6 children
- Monthly maintenance cost \$2 per square metre

14 years
and under

Fitness

Monthly maintenance cost of the fitness centre

Above
14 years



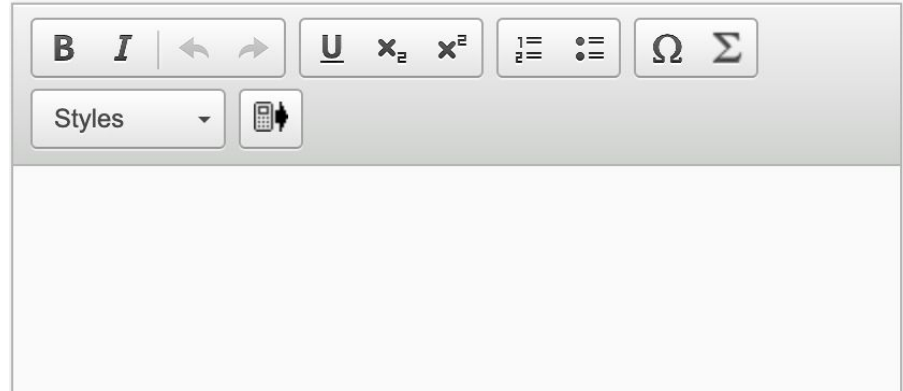
Number of users of fitness centre

Use your results from earlier parts and the information provided.

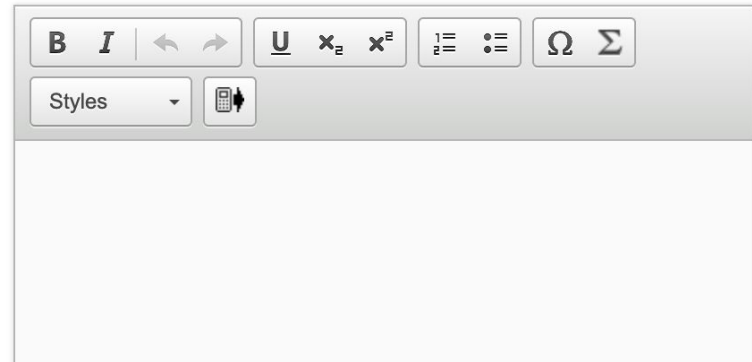
To what extent is the maintenance budget suitable for the recreational area? In your answer you should:

- clearly identify **three** relevant factors
- make calculations for the playground
- make calculations for the total maintenance cost of the recreational area
- show suitable rounding in your working and results
- justify the suitability of the maintenance budget for the recreational area.

Three relevant factors:



Calculations and justification:



Question 7 (30 marks)

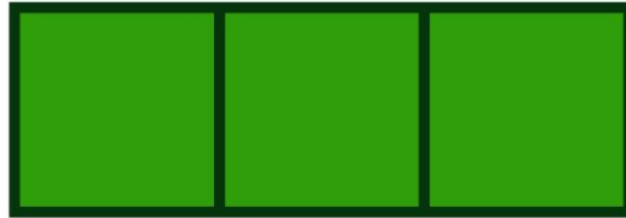
In this part you will investigate geometric patterns formed by squares.
Interact with the stage control to see how the number of squares increase.

Stage 1



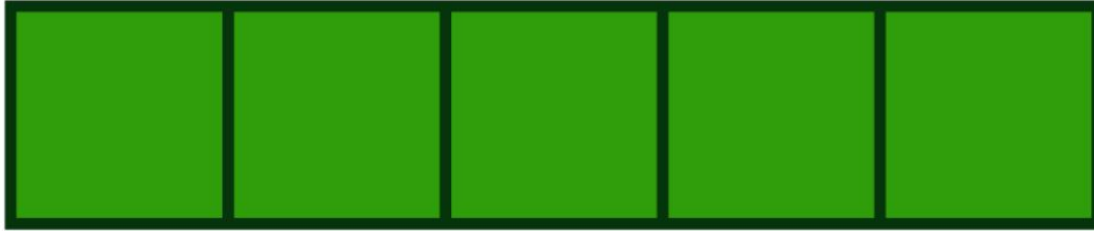
Number of squares = 1

Stage 2



Number of squares = 3

Stage 3



Number of squares = 5

Stage 4



Number of squares = 7

Question 7a (1 mark)

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

Stage number (n)	Number of squares (Q)
1	1
2	3
3	5
4	7
5	
6	

Question 7b (2 marks)

Describe, in words, two patterns in the table for the number of squares (Q).

Question 7c (2 marks)

Write down, in simplest form, a general rule for Q in terms of n .

Question 7d (3 marks)

Verify your general rule for Q.

Bricks are placed on the squares in part (a).

Interact with the stage control to see how the number of bricks increase in each stage.

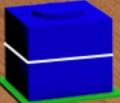


Stage control

Stage 1

Total number of bricks (B) = 2

Number of squares (Q): 1



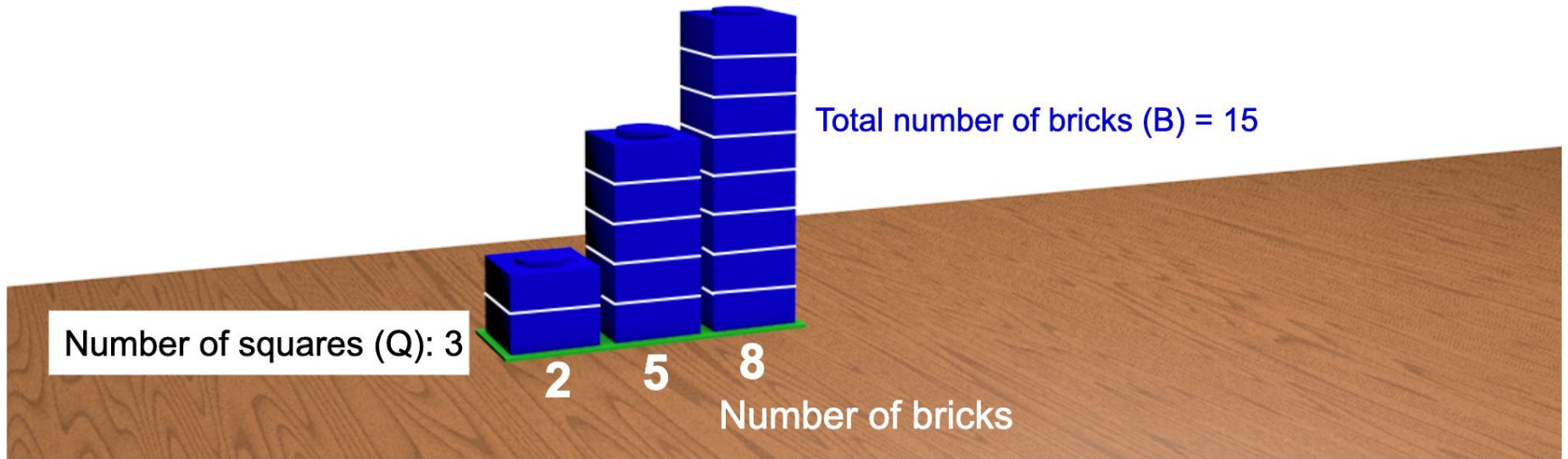
2

Number of bricks



Stage control

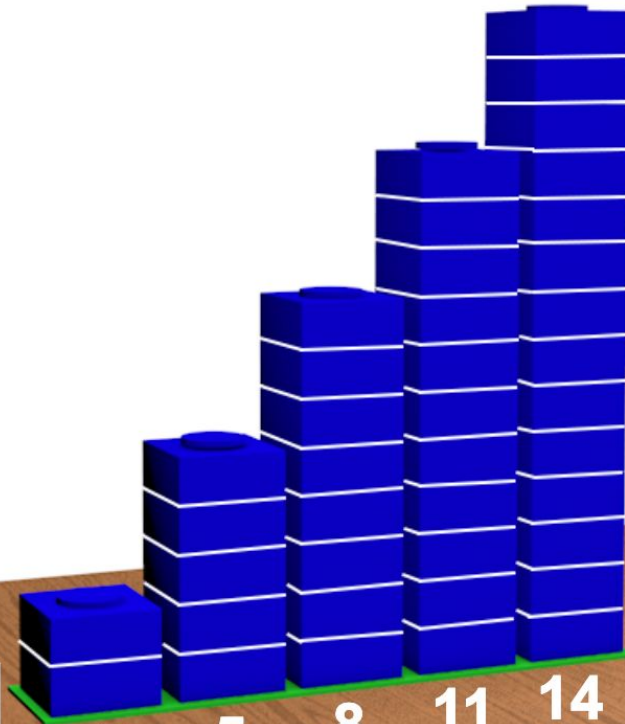
Stage 2





Stage control

Stage 3



Total number of bricks (B) = 40

Number of squares (Q): 5

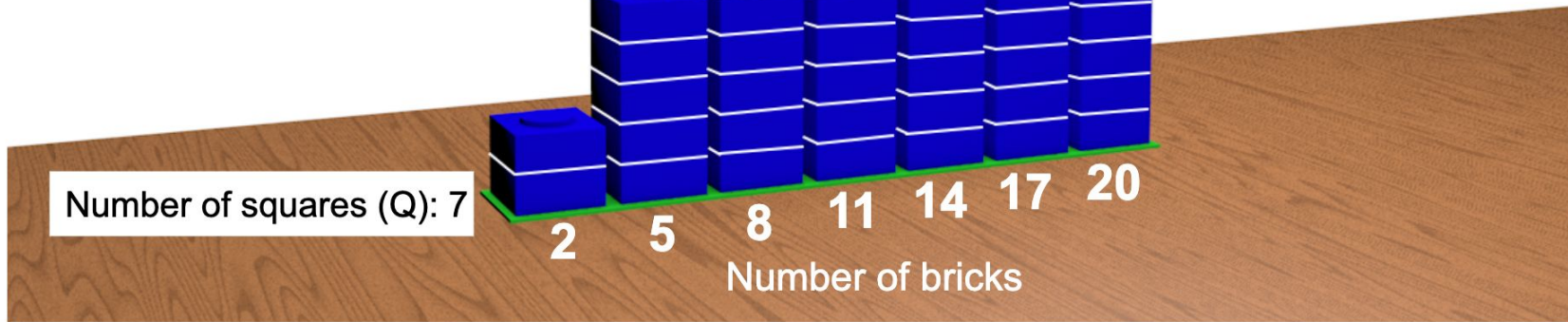
Number of bricks



Stage control

Stage 4

Total number of bricks (B) = 77



Question 7e (1 mark)

The number of bricks placed on the squares follows an arithmetic sequence with first term u_1 and common difference d . **Write down** the values of u_1 and d .

Question 7f (1 mark)

Hence, **show that** the number of bricks on the 7th square is 20.

Question 7g (20 marks)

Stage number (n)	Number of squares (Q)	Total number of bricks (B)		
1	1	2		
2	3	15		
3	5	40		
4	7	77		

Investigate the values in the table to find a relationship for the total number of bricks (B) in each stage in terms of n . In your answer:

- predict more values and record these in the table
- describe in words two patterns in the table for the total number of bricks (B)
- write down, in simplest form, a general rule for B in terms of n
- test and verify your general rule for B
- justify your general rule for B .