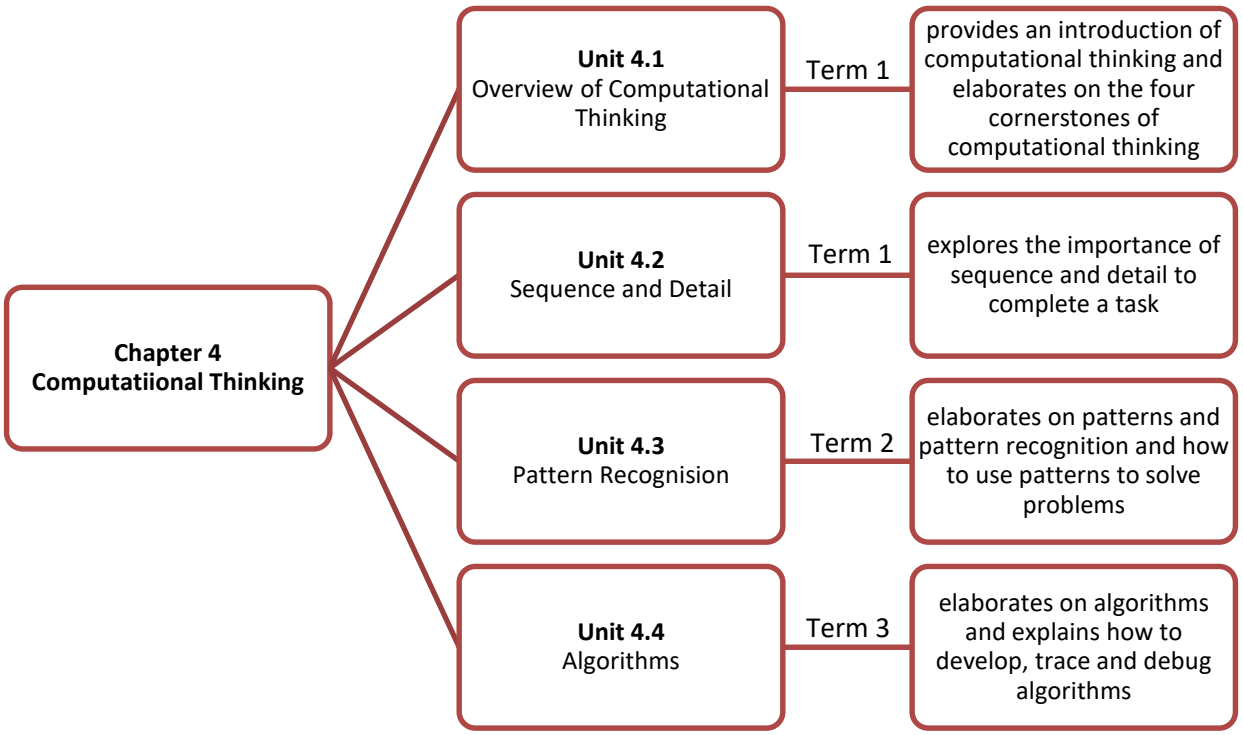
CHAPTER 4: COMPUTATIONAL THINKING

Chapter Overview



Prior Knowledge

No prior knowledge required for this chapter

At the end of the chapter you should be able to:

- describe what computational thinking is
- describe the four cornerstones of computational thinking
- explain how computational thinking helps to complete tasks or solve problems
- describe the steps/rules to complete a task
- explain the importance of sequence and detail when developing instructions
- explain what pattern recognition is and why it is important when solving problems
- Identify a pattern, complete a pattern and generalise a pattern
- explain what an algorithm is and what the characteristics of good algorithms are
- devise an algorithm to perform a task or solve a problem
- trace and debug an algorithm

UNIT 4.1: BASIC CONCEPTS OF COMPUTATIONAL THINKING

In this unit you will learn what computational thinking is and about the four cornerstones of computational thinking.

What Is Computational Thinking?

Computational thinking is an attitude and a skill set where one uses specific techniques and strategies that help one to complete tasks successfully and to solve problems systematically. It further helps us arriving at a solution that both humans and a computer can understand.

Four cornerstones of Computational Thinking

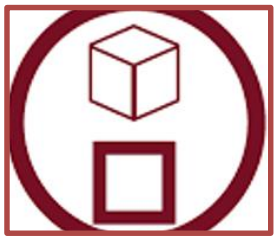
Decomposition

Solving a complex problem by breaking it into small manageable parts where each part is more familiar, straightforward and easier to solve

Pattern Recognition

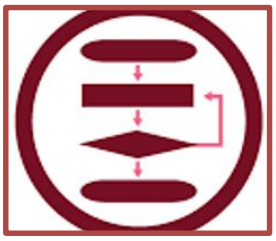
Identifying similarities**.** It helps you to make connections between similar problems and experiences. Recognising the same patterns in other problems helps you in solving a new problem

Abstraction



Focusing on the important and relevant information and ignoring unrelated and irrelevant things or the things you do not need. Simplify something to help you to get to the heart of the problem

Algorithm



Defining a precise sequence of steps or instructions to perform a task.

An algorithm is a set of rules or instructions that anyone can follow to perform a task or solve a problem

Examples of computational thinking in everyday life

Decomposition:

- Cleaning your room by first making your bed, then packing away your clothes, then dusting and then vacuuming the floor.
- You need to fetch 10 ℓ water from the river to your house in the village. You know that you are not strong enough to carry one container with 10ℓ water. You decide to use a 5ℓ container and doing two trips.

Pattern recognition:

- Noticing that all birds have feathers, two wings, a beak and two legs.
- Realising that the difference between terms in a series of even numbers is two, e.g. 10, 12, 14, 16 …

Abstraction:

- Your timetable is an example of abstraction of time and activities. It represents a week in terms of days and periods, helping you to prepare for school and to attend the correct class at the correct time.
- A plan of the school grounds is an abstraction. It helps you to find the building or classroom that you want to go to.

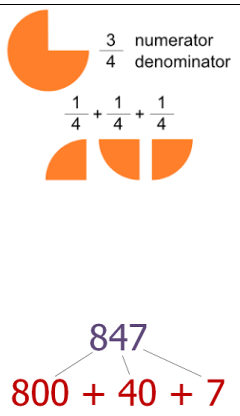
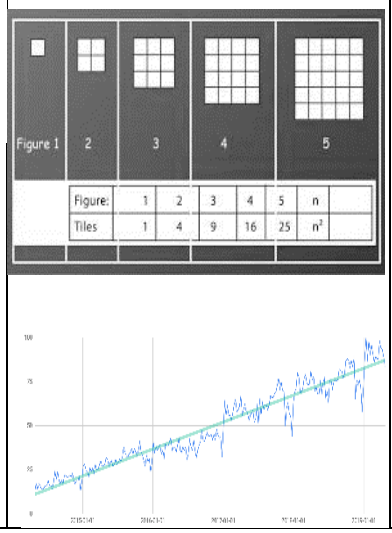
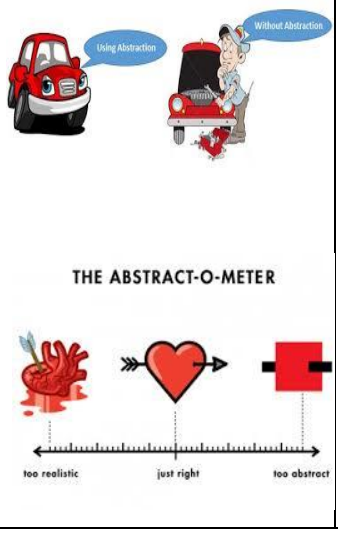
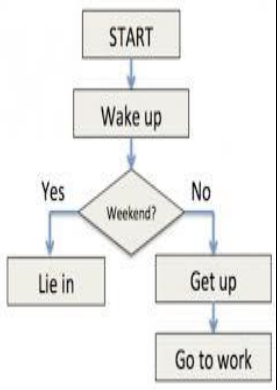
Algorithms:

- Baking a cake following a recipe. The set of rules, steps or instructions to bake a cake is an algorithm.
- Directing someone from your home to the nearest shopping centre.
- A user manual for assembling something or repairing something

From the examples above, one most likely uses computational thinking subconsciously daily. Just think about baking cupcakes. One breaks the task of baking cupcakes into smaller tasks such as preheating the oven, mixing the batter and preparing the icing while the cupcakes are baking – one small task at a time.

One may also use previous experience from baking cupcakes when knowing to bake them slightly longer than the recipe calls for. One also knows that chocolate chips are not a vital ingredient in cupcakes, so one can skip that step if one does not have any available. One also knows to start preheating the oven before pouring the mix into the cups and that, when one takes them out of the oven, one needs to let them cool down before putting on the icing. As one get more experienced, one may also realise that one could prepare the icing the day before.

More examples of computational thinking

Decomposition	Pattern Recognition	Abstraction	Algorithms
			

The importance of computational thinking

Computational thinking lies at the heart of subjects such as programming, data science, cryptography, informatics and artificial intelligence which are becoming indispensable in the information age.

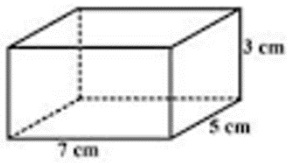
Before computers can be used to solve a problem, one must tell the computer what to do by providing the instructions to complete the task or solve the problem. To provide the instructions one needs to understand the task or the problem itself and the ways in which it could be resolved. Computational thinking techniques enable one to work out the required instructions.

One can use computational thinking to solve a problem by applying the four techniques or cornerstones as described in this unit.

The following activity illustrates how the four pillars of computational thinking are used to solve a problem:

Guided Activity 4.1

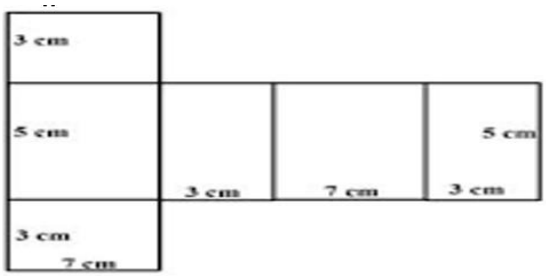
Calculate the outside area of the following 'box':



Abstraction can help with **decomposition**

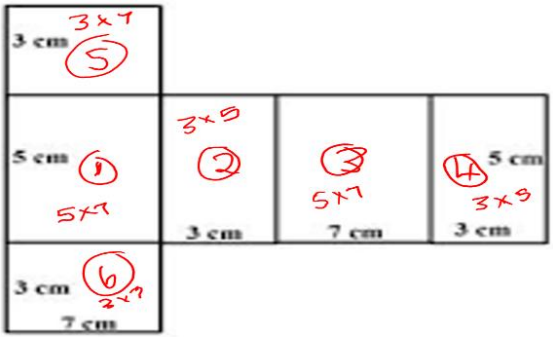
Solving the problem:

- Firstly, **decompose** (break down) the problem, into more familiar ones, using **abstraction**
  - Unfold the figure – this helps to break the problem into smaller parts.
  - Each part can now be solved individually
  - Each 'small' solution can then be combined again to solve the 'big' problem



When we **decompose** problems, we look for **patterns** among and within the smaller problems that make up the complex problem

- Secondly, find **patterns**
  - From the unfolded figure, you should be able to identify **six rectangles**
  - Each rectangle represents 'a side' of the 'box' – bottom, top, front, back, left and right side.
  - The six rectangles can be grouped into three different 'sizes' – the bottom and top rectangles are identical; the front and the back rectangles are identical and the left and the right rectangles are identical.



- Thirdly, develop the **algorithm**

  Outside Area of the box = Area of Top + Area of Bottom + Area of Front + Area of Back + Area of Left side + Area of Right side
  = Area of Rectangle1 + Area of Rectangle3 + Area of Rectangle5 + Area of Rectangle6 + Area of Rectangle2 + Area of Rectangle4

- Fourthly, **solve the problem**

  Outside Area = Top area + Bottom area + Front area + Back area+ Left area + Right area
  = 2(5x7) + 2(3X7) + 2(3X5)
  = 70 + 42 + 30
  = 142m^2

Activity 4.1.1

Watch the following video if you need more clarity on computational thinking

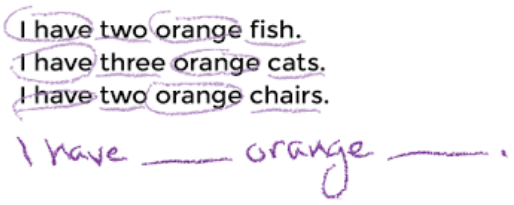
https://www.youtube.com/watch?v=mUXo-S7gzds

1. What is computational thinking?
2. What is the purpose of computational thinking?
3. Describe the four cornerstones of computational thinking by
    a. Describing each cornerstone
    b. Explaining how each cornerstone could be helpful to complete a task or solve a problem.
4. Give an everyday example (other than the ones in this unit) to illustrate each of the four cornerstones.
5. Why is computational thinking important?
6. Identify the applicable cornerstone(s) of computational thinking in each of the following:

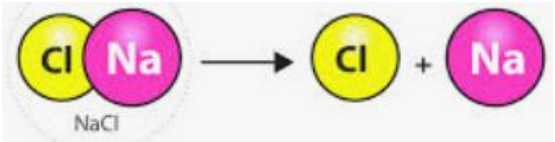
6.1

6.2

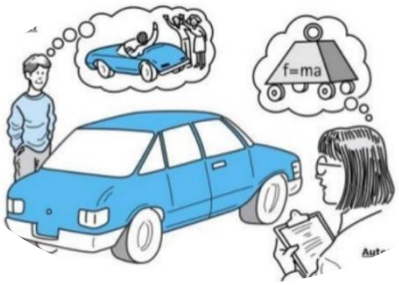
6.3



6.4



6.5



6.6

7. Complete the following pattern:

8. Decompose (break down) the following figure:

9. Write the steps/instructions (algorithm) to make a peanut butter sandwich

10. You are a mobile phone user. Study the list in Column A., then in Column B, apply abstraction by only providing the information that is relevant for you as mobile phone **user**

Column A	**Column B**
Call button	
Code for the call button	
Circuit board of the cellphone	
Swiping the touch screen	
The design techniques for enabling swiping a screen	
The technical features regarding designing and building the camera	
Take photos using the camera	

UNIT 4.2: SEQUENCE AND DETAIL

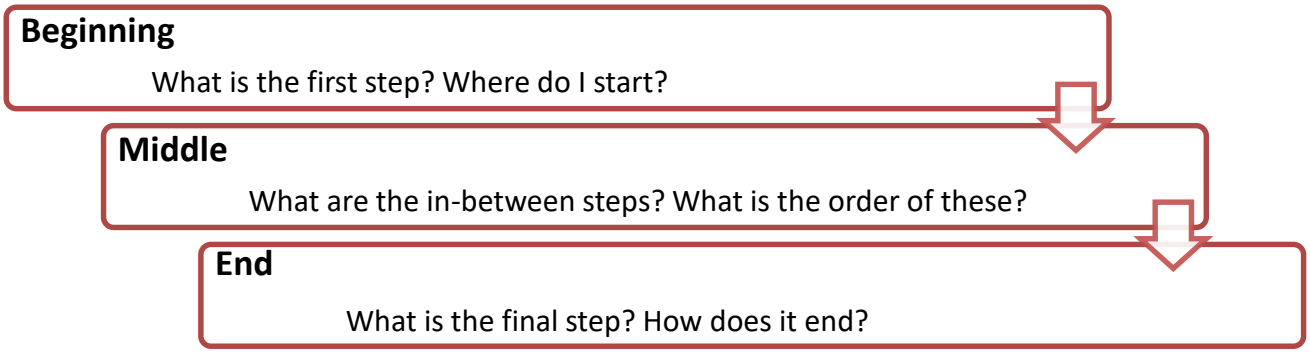
In this unit you will learn what sequencing is and about the importance of sequence and detail when developing steps or instructions to perform tasks.

Sequence

Sequencing is putting events or information in a specific order. It is the skill that helps you to plan ***what*** steps to take ***in which order*** to perform a task successfully.

One of the most important things one must do to perform a task, is to identify the steps required to do so. However, it is also important that the steps are in the correct **sequence** and have the right amount of **detail**. For example, if you need to write down the steps for brushing your teeth, it is important to have the step for taking off the cap of the toothpaste tube before the step to squeeze the tube to put the toothpaste onto the toothbrush.

Every sequence has a beginning, a middle and an end (just like a story).



Example

If one wants to go outside, one will perform the following steps:

Detail

Detail means considering every aspect or minor part of something. It is to describe or give ***exact*** information about something. The steps or instructions to perform a task need to be **unambiguous** – they need to be **precise** and clear to avoid misinterpretation or different interpretations by different people.

Importance of sequence and detail

In **sequencing**, we learn about patterns in relationships and we learn to understand the order of things. By learning to sequence, we develop the ability to understand and arrange purposeful patterns of actions, behaviours, ideas, or thoughts.

Attention to **detail** is important because it helps prevent mistakes and ensures successful completion of a task.

For a computer to perform a task successfully, instructions need to be precise and in the correct order.

Following Instructions

The following activities demonstrate the importance of sequence and detail when developing instructions to perform a task.

Guided Activity 4.2.1

In pairs, answer the following questions:

- What written instructions have you followed to perform a task?
- Were these instructions easy or difficult to follow?
- Why were they easy or difficult to follow?

Guided Activity 4.2.2

A Follow the following instructions *exactly* to draw a picture.

Rules for drawing the picture:

- You cannot ask for help
- You may not look at your friends work (*do it yourself!*)

1. Draw a diagonal line
2. Draw another diagonal line connected to the top of the first one
3. Draw a straight line from the point where the diagonal lines meet
4. Draw a horizontal line over the straight line
5. At the bottom of the straight line, draw a curvy line
6. Draw a diagonal line from the bottom of the first diagonal to the straight line
7. Draw a diagonal line from the bottom of the second diagonal line to the straight line

B How did the pictures turn out?

- Compare your picture with those of your classmates and answer the following questions:
  - Are they different?
  - Why?
  - What was difficult about following the instructions?
  - What was missing from the instructions?

C Your teacher will tell you what the object was that you should have drawn.

D Now that you know what the picture should have looked like, write a set of instructions that some could follow to draw the object. Make sure that

You may have discovered that good instructions/algorithms that work on the first try, are hard to develop

- There is only one way to interpret each step, that is, all instructions are unambiguous
- You break down (decompose) instructions where required
- You provide enough detail in each step

D Write down what you think the characteristics of good instructions or algorithms should be.

Guided Activity 4.2.3

- Watch the following video by clicking on the link or scanning the QR-code: https://www.youtube.com/watch?v=Ct-lOOUqmyY

- Look at the instructions/steps you compiled in Activity 4.1.1 no 9 and discuss what you have learned from the video

Activity 4.2.1

1. Sequence the following steps so that they are in a logical order when you wash your hands:

Turn off the tap

Dry your hands

Rub your hands together

Rinse the soap away with water

Rinse your hands with water

Put soap on your hands

Turn on the tap

2. Complete the following sequence:
   2 4 6 8 10 …

3. Put the following words in alphabetical order:
   Generalisation, Computational Thinking, Algorithm, Coding, Pattern, Decomposition, Sequence, Abstraction, Computation, Sequencing, General

4. Beatrix is trying to rearrange her shelf. She has two rules:
   - Rectangular items must not be next to each other.
   - Circular items must not be next to rectangular items.

   Which one of these shelves has followed her rules correctly?

A 

B 

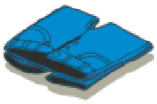
C 

D 

5. You need to make dinner at home for friends. Put the following actions in logical order in order to ensure a successful dinner.
   - ☐ Serve the entrees.
   - ☐ Buy whatever ingredients not on hand in the house.
   - ☐ Say goodbye to the dinner guests.
   - ☐ Start the dishwasher.
   - ☐ Confirm that everyone invited will be coming.
   - ☐ Call and invite some friends for dinner on the weekend.
   - ☐ Check to see everything needed is on hand in the house.
   - ☐ Clear the dishes from the table.
   - ☐ Serve the main course.
   - ☐ Look for ideas for the dinner menu in a cookbook.
   - ☐ Offer you guests something to drink before dinner.
   - ☐ Decide on what the dinner menu will be.
   - ☐ Serve the dessert.
   - ☐ Welcome your dinner guests.
   - ☐ Prepare the food.

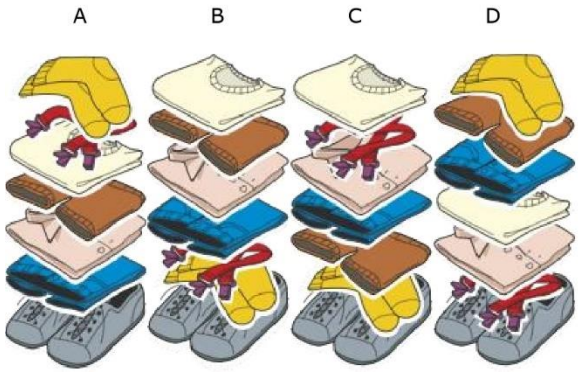
6. Use pen and paper and draw a square by following the sequence of instructions exactly as they are given:
    1. Turn 90 degrees left
    2. Draw a 3 cm line
    3. Turn 90 degrees left
    4. Draw a 3 cm line
    5. Turn 90 degrees left
    6. Draw a 3 cm line
    7. Turn 90 degrees left
    8. Draw a 3 cm line

7. Bruno has seven kinds of clothes:

shirt	T-shirt	pants	underpants	braces	socks	shoes
						

    - Bruno's dad carefully arranges his clothes into four piles
    - Bruno puts on his clothes in the order that they are in the pile, starting from the top of the pile.
    - Bruno wants to wear the braces over his shirt.

    With which piles will Bruno be happy with?



8. You need to explain to someone how to send a WhatsApp message. You received the following on how to send a WhatsApp message:

    - Type message
    - Open WhatsApp
    - Send message

    Rewrite the above instructions to include more steps/detail to make them more precise so that anyone that follows the steps will **exactly** know what to do and be able to perform the task successfully.

    Hand your instructions to a friend to check your instructions for sequence and detail.

9. You have two containers – an empty container and a container with milk. You also have a glass filled with orange juice. You want to pour the milk into the glass to drink, but you also want to save the orange juice for later.

Two different people compiled instructions to achieve the task using the available objects only: the two containers and the one glass filled with orange juice. However, the instructions do not seem to work properly.

Study the different instructions. None of the instructions are working correctly. Use the instructions and write you own set of precise instructions so that the task can be achieved in the most efficient (the shortest and best way without mixing the milk and orange juice in any way) manner and be understood by anyone following it:

Instruction set 1	**Instruction set 2**
1. Take off the cap from the milk container 2. Pour the milk into the empty container 3. Put the cap back on the container 4. Pour the orange juice into the milk container 5. Put the cap onto the container now containing the orange juice 6. Rinse the glass 7. Pour the milk into the glass 8. Drink the milk 9. Put the container with the orange juice in the fridge	1. Take off the cap from the empty container 2. Pour the orange juice into the empty container 3. Pour the milk into the glass 4. Put the cap back on the now empty container 5. Rinse the glass 6. Rinse the now empty container 7. Put the container with the orange juice back in the fridge 8. Put the cap on orange juice container 9. Drink the milk

Answer the following questions:

i) Why did you need an extra (empty) container?

ii) Give your instructions to a friend to test and evaluate.

10. The ASCII-value of letters are as follows:

ASCII is a character encoding standard for electronic communication. ASCII codes represent text in computers

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122

ASCII values of special characters:

- The ASCII value for the **space** is **32**
- ASCII value of the **apostrophe** (**'**) is **39**
- ASCII value of hyphen (**-**) is **45**

A computer sorts characters according to ASCII codes

Arrange the following surnames alphabetically according to the ASCII-values:

Nel, McCracken, Dada, de Lange, le Clerque, Mudau, van Buuren, De Lange, Vandeventer, Delport, MCDonald, Nell, Van Deventer, O'Niel, Naidoo, Mini, StBernard, Leclerque, Nel-Pieters, Olwage

UNIT 4.3 PATTERN RECOGNITION

In Unit 4.1 you learned what pattern recognition is and why it is important when performing tasks or solving problems.

Guided Activity 4.1.1 also showed that when we break down a complex problem into smaller parts (decompose), we often find patterns among the smaller parts.

What are patterns?

Patterns are things that are the same within a problem or between problems.

Example:

Let us look at the instructions for drawing a square from Activity 4.2.1 no 5 and see if we could identify a pattern:

1. Turn 90 degrees left
2. Draw a 3 cm line
3. Turn 90 degrees left
4. Draw a 3 cm line
5. Turn 90 degrees left
6. Draw a 3 cm line
7. Turn 90 degrees left
8. Draw a 3 cm line

1
2
3
4

The instructions follow a specific pattern: the same two instructions are repeated four times

By identifying the pattern, we could shorten the instructions as follows:

Repeat **4** times

Turn 90 degrees left
Draw a 3 cm line

What is pattern recognition?

Pattern recognition is identifying patterns such as patterns in data, biometrics (fingerprint, iris). For example, patterns in data tell the stories of data through increasing, declining and flat lines. The data itself can be anything such as text, images, sound, numeric data (numbers), shapes and others. Any information of sequential nature can be processed by pattern recognition algorithms, e.g. detecting plagiarism.

Pattern recognition is based on the five key steps of:

- Identifying **common elements** in problems or tasks
- Identifying and interpreting **common differences** in problems or tasks
- Identifying **individual elements** within problems or tasks
- **Describing patterns** that have been identified
- Making **predictions** based on identified patterns.

Predictions are the connecting links between what you already know with new information or knowledge

How are patterns and pattern recognition helpful?

- Identifying patterns can point you to an existing solution that you can use to solve a new problem.
- Patterns help us to make **predictions**
- Pattern recognition helps us to **generalise**

To **generalise** is to look at specific cases; identify a pattern or relationship that will always be true; then represent the pattern in symbolic format

Example:

Study at the following text: A A B A A C A A D A A B A A B A

Find the following pattern within the above text: A A B A

Pattern found in three instances at positions 0, 9 and 12:

A A B A A A B A

A A B A A C A A D A A B A A B A
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

A A B A

Guidelines to recognise patterns

Actively look for patterns

- Observe the environment or look at steps/instructions, data or information to find patterns and trends

Organise pieces

- Lay out data into visual format to make sense of existing connections and to form new associations, i.e. organise it into chunks or groups that will help you to find patterns or trends.

Question data

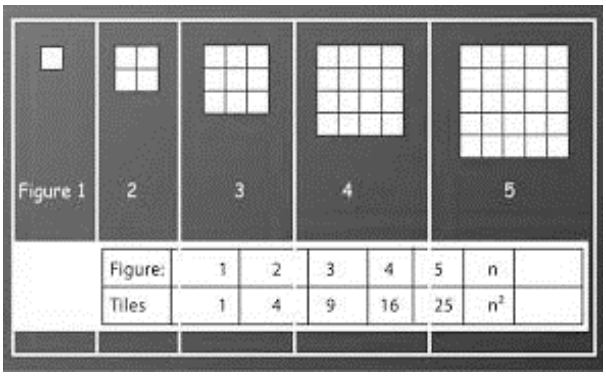
- Questions such as: Who?, What?, How much?, Where?, When?, Why?, e.g.
  - What is missing?
  - What is the difference?
  - How is it similar?

Visualise data

- Visualise the data using graphs, maps, pictures, to see if patterns/trends are emerging

Guided activity 4.3

Study the pattern in the following diagram:



Identifying the number of rows and columns in the sequence helps to see the pattern:

1 row/column → 1 small square blocks
2 rows/columns → 4 small square blocks
:
5 rows/columns → 25 small square blocks

The pattern then helps us to make **predictions**, that is to **predict** that the next item (after 5 rows/columns) would be:

6 rows/columns with 36 small square blocks followed by 7 rows columns with 49 small square blocks, etc.

The pattern also helps us to **generalise**, that is to see a relationship that enables us to devise a symbolic representation of the pattern that will always be true. In this instance there is a relationship between the number of rows/columns and the number of small square blocks in the figure that one can represent in symbolic format as:

n rows/columns → **n^2** number of small square blocks

If one therefore wants to know how many small square blocks the 20^{th} item would have, one could simply use the generalised formula: 20 rows/columns → 20^2 small blocks, that is 400 small square blocks.

Activity 4.3.1

1. Which of the five is least like the others?

   A. razz B. poss C. simm D. loop E. nett

2. Which one of the five choices makes the best comparison?
   PEACH is to HCAEP as 46251 is to:

   A. 25641 B. 26451 C. 12654 D. 51462 E. 15264

3. Which one of the five choices makes the best comparison?
   Finger is to Hand as Leaf is to:

   A. Twig B. Tree C. Branch D. Blossom E. Bark

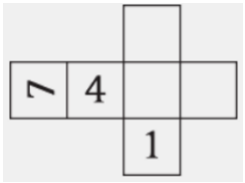
4. Study the following pattern:
   1 – 2 – 4 – 8 – 16 …

   Identify and describe the pattern.

5. Which one of the numbers does not belong in the following series?
   2 – 3 – 6 – 7 – 8 – 14 – 15 – 30

   A. Three (3) B. Seven (7) C. Eight (8) D. Fifteen (15) E. Thirty (30)

6. What does the cube look like if it is folded together?



   A.  B.  C.  D.  E. 

7. If all Bloops are Razzies and all Razzies are Lazzies, all Bloops are definitely Lazzies

   True or **False**?

8. Water is to pipe as **?** is to wire

   A. cord B. line C. electricity D. heat E. gas

9. How many times does the pattern **0010** appear in the following text:
00110001011001001 0010

   A. 1 B. 2 C. 3 D. 4 E. 5

10. Emily has broken her favourite bracelet. The broken bracelet now looks like this:

Which of the following four bracelets shows what the bracelet looked like when it was whole?

A 

B 

C 

D 

11. Which number should come next in the series?

1 – 1 – 2 – 3 – 5 – 8 – 13 – …

A. 8 B. 13 C. 21 D. 26 E. 31

12. Which one of the figures should logically be in the spot of the question mark?

A. 

B. 

C. 

D. 

E. 

13. Which one of the following figures can be made from the loose parts:

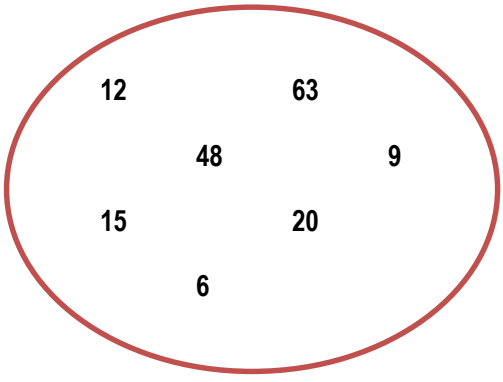
A 

B 

C 

D 

14. Which number does not logically belong with the others:



15. A *Latin square* has two important properties:
    - A row or column never contains the same figure/number twice
    - Every row and column contain the same figures/numbers

    On the right-hand side is an example of a full Latin square

1	2	3	4
2	3	4	1
3	4	1	2
4	1	2	3

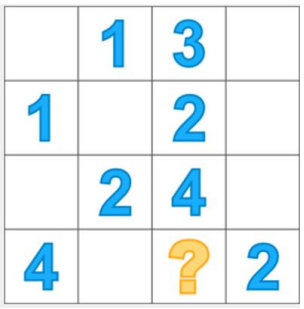
    For each of the figures below (i – vi), figure out which of the four numbers belongs in the place of the question mark.

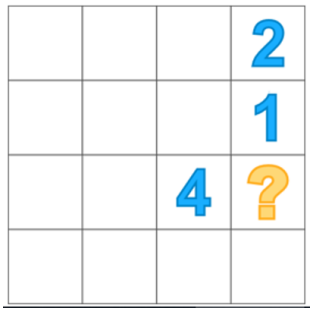
A 

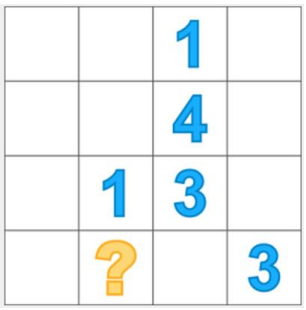
B 

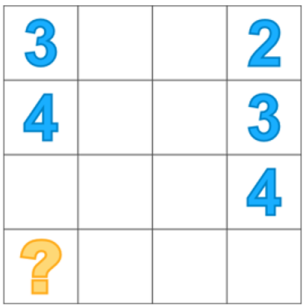
C 

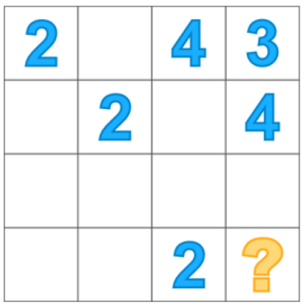
D 

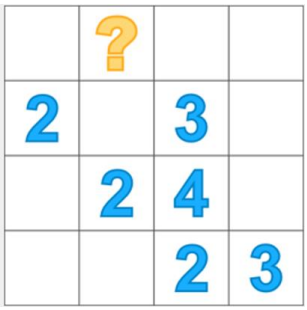
i) 

ii) 

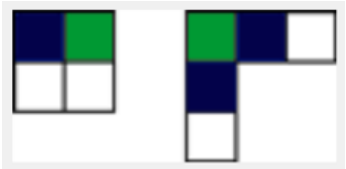
iii) 

iv) 

v) 

vi) 

16. Which larger shape would be made if the two figures are fitted together:



A 

B 

C 

D 

17. Complete the following pattern:

    4 6 9 6 14 6 …

18. Three spotlights are used to light the theatre stage, a red one, a green one and a blue one. The colour of the stage depends on which of the three spotlights are turned on.

The table below shows the possible combinations of colours.

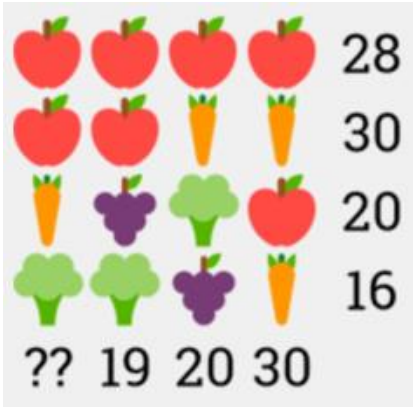
Red light	Green light	Blue light	Stage colour
off	off	off	Black
off	off	on	Blue
off	on	off	Green
off	on	on	Cyan
on	off	off	Red
on	off	on	Magenta
on	on	off	Yellow
on	on	on	White

From the beginning of the show, the lights will be switched on and off in the following pattern:

- The red light repeats the sequence: two minutes off, two minutes on.
- The green light repeats the sequence: one minute off, one minute on.
- The blue light repeats the sequence: four minutes on, four minutes off.

What will the colour of the stage be in the first 4 minutes of the show?

19. The numbers alongside each column and row in the drawing below are the sums of the values represented by the symbols within each column and row. Study the patterns and figure out what number should replace the question marks.



A. 23

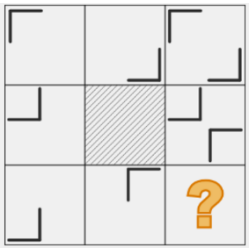
B. 25

C. 28

D. 30

E. 32

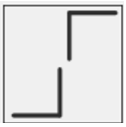
20. Which one of the figures should logically be in the spot of the question mark?



A 

B 

C 

D 

21. You have done the algorithm for a square (4 corners, 4 sides) and a triangle (3 corners, 3 sides). Let us look at other geometrical figures: pentagon, hexagon, heptagon and octagon. Could there be a relationship between all these figures?

i) Complete the following table to determine a possible relationship

	Square	**Pentagon**	**Hexagon**	**Heptagon**	**Octagon**
					
Number of sides	4	5	6	7	8
Number of angles	4	5	6	7	8
Size of interior angle	90°	72°	60°	51,4°	45°
Sum of interior angles	360°	360°	360°	360°	360°

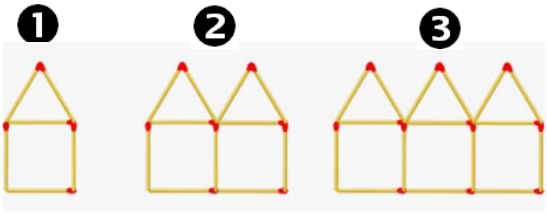
i) What do you notice about the form of the shapes when the number of sides increases?

ii) What happens with the size of the interior angles when the number of sides of the figures increases?

iii) What do you notice about the sum of the interior angles?

iv) Describe the pattern/relationship.

22. Study the following picture. Each house pattern is built using a certain number of match sticks.



i) Complete the following table for pattern no 4, 7 and no 10

No of houses	**1**	**2**	**3**	**4**	**…**	**7**	**…**	**10**
Number of match sticks used	6	11	16					

ii) From the table above, Identify and describe the pattern.

iii) Look for a relationship between the **number of match sticks** and the **number of houses**, e.g. to build the single house (pattern no **1**), you need **6** match sticks and for the two houses (pattern no **2**) you need **11** match sticks, etc.

No of houses	**1**	**2**	**3**	4	…	**7**	…	**10**
Number of match sticks used	**5** + 1	**10** + 1	**15** + 1					

+5 +5

Complete the table and describe the pattern between the pattern no and the number of match sticks, e.g. **1** and **5**; **2** and **10**, etc.

iv) If **n** is the pattern no, use the relationship from above **generalise** the pattern and represent the generalised pattern in symbolic format (using **n**) for each of the pattern numbers below

No of houses	**1**	**2**	**3**	**4**	**…**	**n**	**150**
Number of match sticks used							

23. A Ceasar cipher (named after the Roman Emperor Julius Ceasar) is a simple **encryption** method in which each letter in a word is replaced by another letter in the alphabet, depending on the 'shift' key.

Encryption is to convert information or data into secret code

The alphabet can be shifted up to 25 places but shifting it 26 places takes it back to its original position and shifting it 27 places is the same as shifting it 1 place.

For example, if the 'shift' key is 7, the letter A will be replaced by the letter H (as shifting 7 positions from position 1 takes one to the 8th letter in the alphabet (H) – H therefore becomes the 1st letter of the 'new' (shifted) alphabet as shown below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G

Therefore, the encryption for the word 'HELLO', will become 'OLSSV'.

Do the following:

i) Use the above information to encrypt the following message: EIGHT NOON AT CAGE

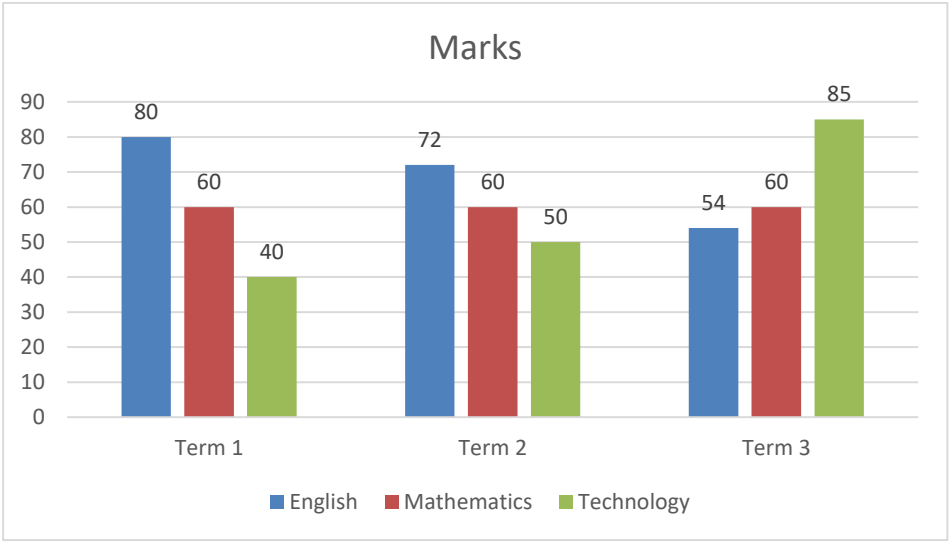
ii) **Decrypt**– the opposite of **encrypt** (i.e. crack the secret message) the following secret message WHZZDVYK PZ JLHZHY

iii) Use your own key to encrypt the following message:

iv) Give your encrypted message with the key to a friend and ask your friend to decrypt the message.

Decryption is to convert a secret (***encrypted***) message to an understandable (***decrypted***) message

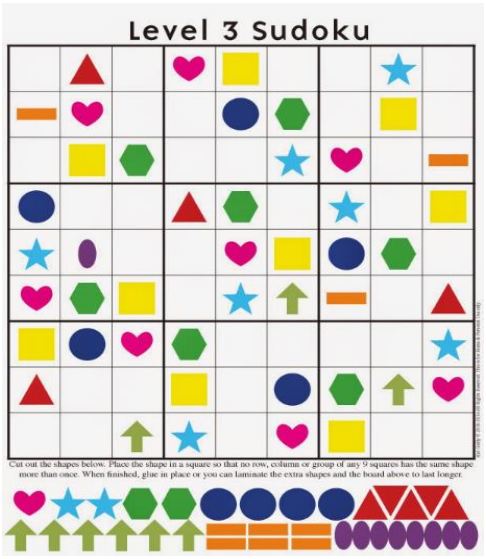
24. Use the following chart to predict the marks for each of the subjects for Term 4.



25. The classic Sudoku game involves a grid of 81 squares (nine 3x3 squares). The grid is divided into nine blocks, each containing nine squares. The rules of the game are simple: each of the nine blocks must contain all the numbers 1-9 within its squares. Each number can only appear once in a row, column or box.

    Use your pattern recognition skills to solve the puzzles!

		7	9	6	2	4		
9				1				2
	1		8	5	3		6	
5			4	7	9			1
				8				
4			3	2	1			7
	9		2	4	8		5	
6				3				8
		8	6	9	5	1		



UNIT 4.4 ALGORITHMS

In Unit 4.1 we learned what an algorithm is and in Unit 4.2 we learned that sequence and detail are important when we develop a set of instructions or algorithms to perform tasks or solve problems. In Unit 4.3 we learned that identifying patterns or similarities could help to identify steps or instructions for solving problems or performing tasks, especially of the problem or task is like one previously experienced.

What is an algorithm?

An algorithm is an ordered list of well-defined steps or instructions to follow in order to perform a task or solve a problem.

When developing and algorithm, each instruction is identified and the sequence in which the instructions are carried out, is planned and should be logical.

What makes a good algorithm?

Some algorithms are better than others. So, what should we consider when we design algorithms that will ensure they are good algorithms, especially if the algorithm must be understood by non-humans such as a computer or a robot?

Firstly, there should be a begin and an end (like in a story) – a limited number of steps or instructions.

Secondly, the steps or instructions must be:

- Easy to understand and follow
- Detailed and specific
- Clear and unambiguous
- In the correct, logical sequence
- Complete – it solves every aspect of the problem
- Efficient – solves the problem making best use of resources, e.g. takes the shortest route

Thirdly, each step or instruction should

- Consist of a single task
- Be at the most basic level that cannot be broken into simpler tasks

Fourthly, there must be at least one result (output or accomplishment)

Guidelines on how to develop an algorithm

- **Understand the problem**
  - Read the problem statement carefully to understand what the problem is that you need to solve
- **Analyse the problem**
  - What should the output (result) be?
  - What are the inputs to get to the output?
  - What processing (if any) needs to be done to get to the output?
- **Develop a high-level algorithm**

A **high-level algorithm** includes only the **main** steps or instructions of the solution and leaves the details until later

- **Refine** the algorithm by decomposing steps (breaking steps down into smaller tasks) or instructions and adding more detail

Refinement is a process for developing a detailed algorithm by gradually adding detail to a **high-level algorithm**

- **Test** the algorithm – follow the instructions to see if it delivers the desired output
    - Does the solution or output make sense?
    - Is the sequence logical?
    - Is the algorithm efficient?
    - Are all parts of the problem or task covered?
    - Are some instructions or tasks repeated unnecessarily?
- **Update** or correct the algorithm if necessary.

Guided Activity 4.4

Consider the characteristics that make good algorithms and use the guidelines for developing an algorithm to solve the following problem:

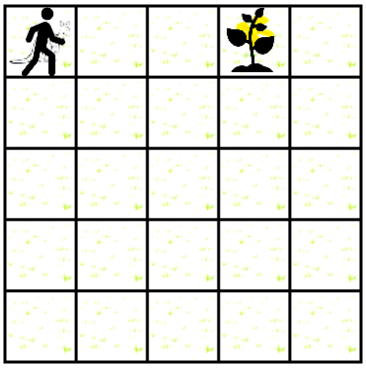
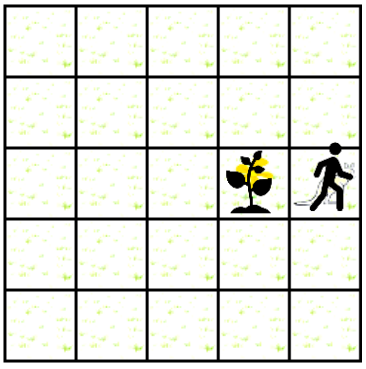
Problem:
Katlego needs to replant a flower in a different position (see diagram below).

Step 1: Understand the problem

Katlego starts at (0, 0) facing East with no flowers in his hand. There is a flower at location (3, 0).

Highlight the **relevant** information, while ignoring unimportant or irrelevant information (**abstraction**)

Write a program that directs Katlego to pick the flower and plant it at location (3, 2). After planting the flower, Katlego should move one space East and stop. There are no obstacles, other flowers, or people on the island.

Start	Finish
	

Step 2: Analyse the problem

- Katlego is on the top left block of the grid (position (0, 0))
- The flower must be planted at position (3, 2)
- The flower is exactly three spaces ahead of the Katlego.
- The flower is to be planted exactly two spaces South of its current location.
- Katlego is to finish facing East one space East of the planted flower.
- There are no obstacles or other people to worry about.

Step 3: Develop a high-level algorithm

Bobby should do the following:

1. Get the flower
2. Put the flower
3. Move East

The **high-level algorithm** breaks the problem into ***three*** rather easy **sub-problems**.
This seems like a good technique.

Step 4: Detailed Algorithm

Bobby should do the following:

1. Get the flower
   1.1. Move 3 times
   1.2. Pick the flower
2. Put the flower
   2.1. Turn right
   2.2. Move 2 times
   2.3. Plant the flower
3. Move East
   3.1. Turn left
   3.2. Move once

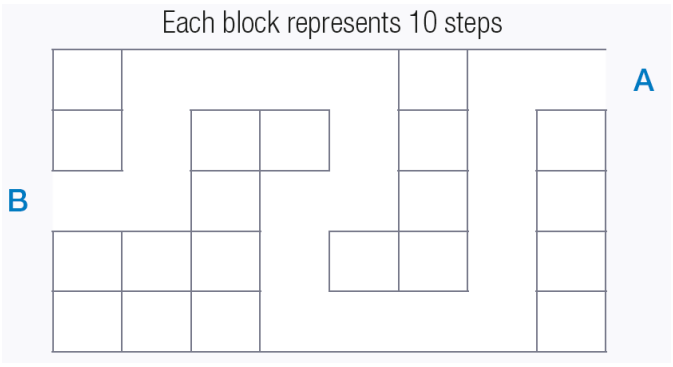
Each step in the **high-level algorithm** was broken down into more specific, detailed steps, giving more detailed instructions.

Step 5: Test the algorithm

- Draw a grid and put two objects (one representing Katlego and one representing the flower) in the correct positions on the grid.
- Follow the algorithm and move the objects representing Katlego and the flower according to the instructions (algorithm)
- Ask the following questions:
  - Was the flower successfully moved from its first position to the target position?
  - If the answer is yes, the problem is solved else you need to identify the error and fix the algorithm.

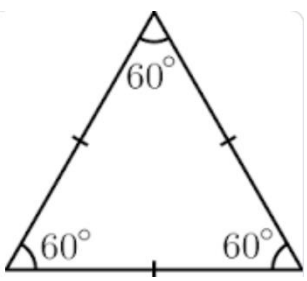
Activity 4.4.1

1. Create an algorithm to move from point A to point B. One block represents 10 steps.

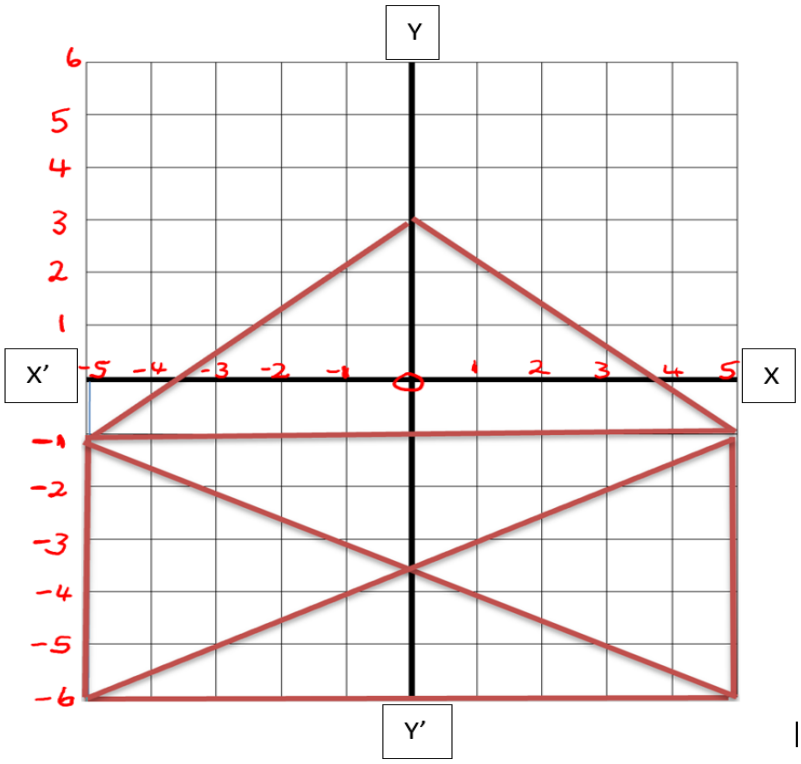


2. Refer to the example drawing a square in Unit 4.3 and develop an algorithm to draw an equilateral triangle

   Give your completed algorithm to a friend to test and evaluate.



3. You need to draw a house with a cross on the walls as shown below:



You must follow the following 'rules' when drawing the house:

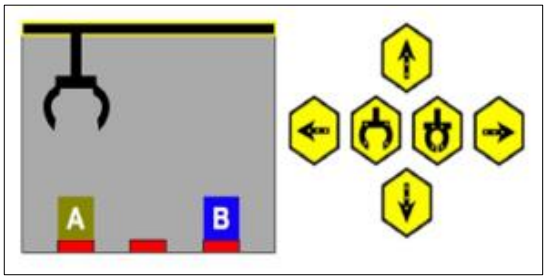
- You may not lift your hand/pen
- You may not draw on a line that has already been drawn

Someone created two algorithms for drawing the house according to the above rules. Follow each algorithm to see if it complies with the rules above. If you find that the algorithm does not comply with the rules, rewrite it so that it is in line with the rules.

The coordinates are in the format (x,y), e.g. (1, 2) refers to x=1 and y=2 on the grid.

Algorithm 1	Algorithm 2
1. Start at (5, –1)	1. Start at (5, –6)
2. From the above position, draw a diagonal line to (–5, –6)	2. From the above position, draw a diagonal line to (–5, –1)
3. From the position in step 2, draw a straight line to (5, –6)	3. From the position in step 2, draw a straight line to (5, –1)
4. From the position in step 3, draw a diagonal line to (–5, –1)	4. From the position in step 3, draw a diagonal line to (–5, –6)
5. From the position in step 4, draw a diagonal line to (0, 3)	5. From the position in step 4, draw a straight line to (5, –6)
6. From the position in step 5, draw a diagonal line to (5, –1)	6. From the position in step 5, draw a straight line to (5, –1)
7. From the position in step 6, draw a straight line to (5, –6)	7. From the position in step 6, draw a diagonal line to (0, 3)
8. From the position in step 2, draw a straight line to (–5, –1)	8. From the position in step 7, draw a diagonal line to (–5, –1)
9. From the position in step 8, draw a straight line to (5, –1)	9. From the position in step 8, draw a straight line to (–5, –6)

4. The crane in the port of Durban responds to six different input commands:



1. Left
2. Right
3. Up
4. Down
5. Grab
6. Release

Crate A is in the left position, crate B is in the position on the right

i) Which is the correct set of instructions to swap the position of the two crates? Write down the letter of the correct answer.

A (Down, Grab, Up, Right, Down, Release, Up)

B (Down, Grab, Up, Right, Down, Release, Up) (Right, Down, Grab, Up, Left, Left. Down, Release, Up) (Right, Down, Grab, Up, Right, Down, Release)

C (Right, Right, Down, Grab, Up) (Left, Left, Down, Release, Up)

D (Down, Grab, Up, Right, Right, Down, Release, Up) (Down, Grab, Left, Down, Release, Up) (Down, Grab, Up, Right, Down, Release, Up

ii) What has this activity in common with Activity no 4.2.1 no 7 (2 containers and glass)?

5. Your teacher wants to take the name and surname of a person and convert it to the initial of the name and initial of the surname only, e.g. **Ben Ten** becomes **BT**

The names are written in blocks as shown:

M	**A**	**R**	**Y**		**P**	**O**	**P**	**P**	**I**	**N**	**S**
D	**O**	**N**	**A**	**L**	**D**		**D**	**U**	**C**	**K**	
N	**A**	**L**	**I**		**B**	**A**	**L**	**I**			
B	**E**	**N**		**T**	**E**	**N**					

Someone came up with the following algorithm:

1. Go to the beginning of the first row
2. Take the letter in the first block and write it down
3. Go to the first empty block
4. Go to the next block, take the letter in the block and write it down
5. Go to the beginning of the second row
6. Take the letter in the first block and write it down
7. Go to the first empty block
8. Go to the next block, take the letter in the block and write it down
9. Go to the beginning of the third row
10. Take the letter in the first block and write it down
11. Go to the first empty block
12. Go to the next block, take the letter in the block and write it down

i) Identify and describe the pattern within the algorithm

ii) What will happen if the list contains 40 names and surnames?

iii) How would it be possible to shorten the algorithm?

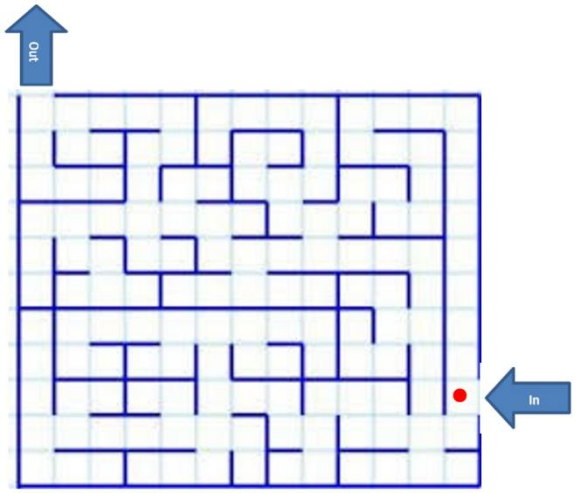
iv) How could we use generalisation to make the algorithm work for any number of learner names and surnames?

6. Vuyo needs to walk through the maze from the entrance to the exit.

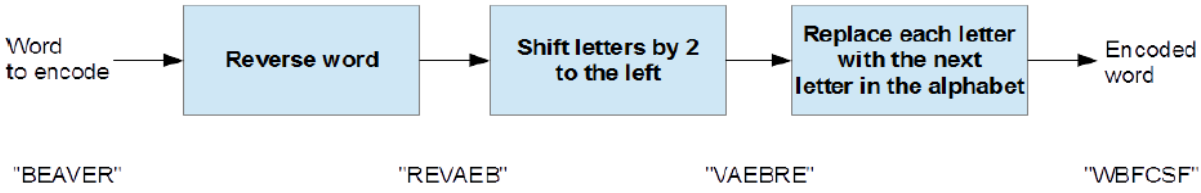
   Below are instructions someone started but did not complete:

   Enter the maze (step onto the red dot)
   Turn right, Walk 8 steps, Turn left, Walk 3 steps
   Turn left, Walk 1 step, Turn left, Walk 2 steps
   Turn left

   Complete the instructions (algorithm) that will guide Vuyo through the maze successfully.



7. Agent Sipho and Agent Alice send each other encrypted messages using the following algorithm.



   i) Study the encryption algorithm and write the algorithm to **decrypt** the message

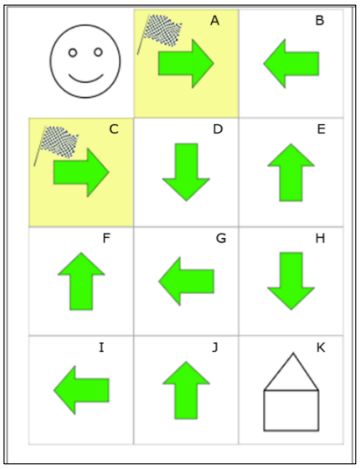
   ii) Agent Alice receives the encrypted message “PMGEP" from Agent Sipho. Use your decryption algorithm to decode the message and write down the decoded message.

8. Help Smiley get through the arrow maze back to his house.

   When standing in a square with an arrow, Smiley must move to the next square by following the direction of the arrow. Smiley can choose to start from either shaded square with a start flag.

   At the moment it is impossible for Smiley to reach his house. By changing the direction of one of the arrows, Smiley will be able to follow the arrow to his home.

   Which arrow needs to change direction? Write down the letter of the arrow that needs to change and indicate in which direction it needs to change.



9. Refer to Guided Activity 4.3.1 and write the steps (understand the problem, analyse the problem, develop a high-level algorithm, develop a detailed algorithm and test the algorithm) to develop the algorithm for the following problem:

   Problem

   Robocop must draw a smiley face on the grid.

   It first must pick up the bucket with paint; paint the blocks to resemble the smiley and then put away the paint bucket where it was picked up and return to its starting position. Robocop may not walk on an area that was painted.

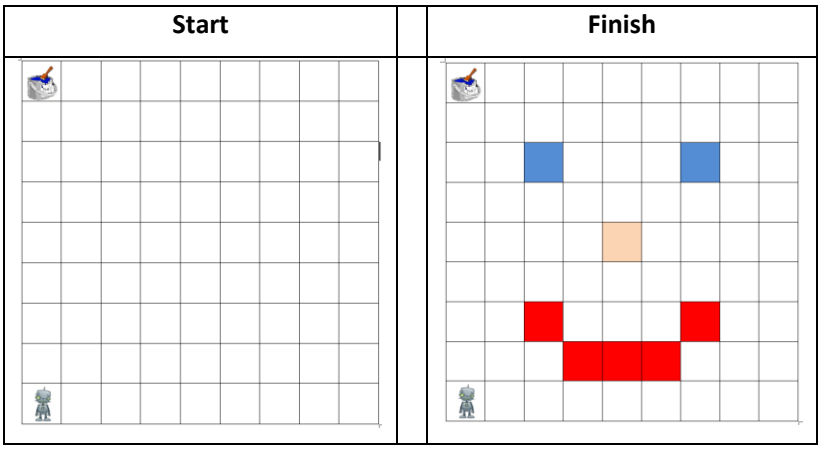
i) Understand the problem

ii) Analyse the problem

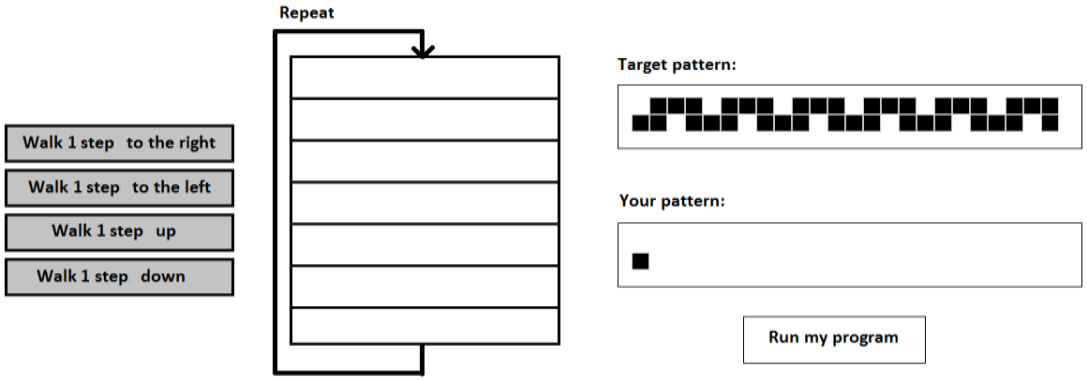
iii) Develop high-level algorithm

iv) Develop detailed algorithm

v) Test the algorithm (ask a friend to test your algorithm and provide feedback)

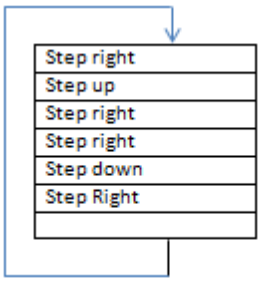


10. Use the four instructions provided, the repeat structure and the one-block pattern to draw the target pattern.

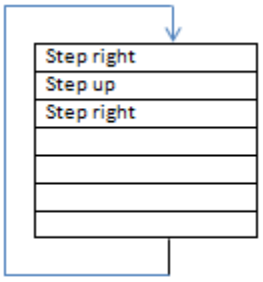


i) Select the sequence of instructions that draws the image (target pattern) shown above.

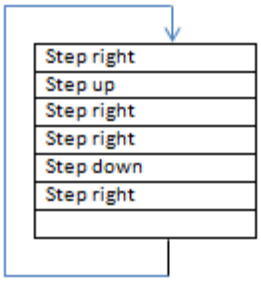
A.



B.



C.



D.