UK Bebras Computational Thinking Challenge

www.bebras.uk

2014

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Introduction

The UK Bebras Computational Challenge is an online competition open to students in the UK and English speaking International Schools around the World. It requires intelligence, but no previous knowledge. It is hoped it will raise general interest in youngsters in Computer Science and help them to understand that Computational Thinking has wide application in solving all sorts of problems they might meet in life. The philosophy emphasises participation whilst celebrating achievement.

This competition is anything but unique to the UK. Last year the International Bebras Competiton celebrated its 10th year. For the UK it was its first official year. That being said, we entered over 21,000 students. In 2013 in total 680,000 students from 26 countries participated.

On the following pages you will find the 30 tasks used in the UK Bebras 2014. Above each question is noted which age groups and at what level the questions were used.

After each question there is an answer, an explanation of how the answer could be obtained plus a section on how the tasks are related to Computational Thinking. (FYI the rest of the world call this Informatics.) We have also mapped the tasks to the Computational Thinking Concepts that feature in the Progression Pathways Assessment Framework created by Mark Dorling. It is our sincere hope that this Computational Thinking information provided will enhance the usefulness of this booklet for Computer Science teachers and their students whether in the Primary or Secondary phase. It is for this reason that this booklet is being distributed to as many schools as possible and made freely available as a PDF that can be distributed freely.

The 2014 competition was conducted in six age groups:

England and Wales	Scotland	Northern Ireland
Elite: Years 12 & 13 Higher: Years 10 & 11 Intermediate: Years 8 & 9 Junior: Years 6 & 7 Castors*: Years 4 & 5 Kits*: Years 2 & 3	Elite Years S5 & S6 Higher: Years S3 & S4 Intermediate: S1 & S2 Junior: Years P6 & P7 Castors*: Years P4 & P5 Kits*: Years P2 & P3	Elite: Years 13 & 14 Higher: Years 11 & 12 Intermediate: Years 9 & 10 Junior: Years 7 & 8 Castors*: Years 5 & 6 Kits*: Years 3 & 4

* pilot year for these groups – Castors and Kits can enter individually or as small teams (up to 4)

Introduction

The contest is completed online in schools under the supervision of teachers.

For Elite, Higher, Intermediate and Juniors there were 15 multiple-choice questions to be attempted in 40 minutes.

Castors had 10 questions to attempt in 40 minutes.
Individuals or small teams were allowed to enter.

Kits had 6 questions to attempt in 40 minutes.
Individuals or small teams were allowed to enter.

The organisers wish to pass on a special thanks to all the teachers who have made it possible for their students to enter into this competition by taking on a huge amount of the necessary administration for us. We invite schools to participate again in November 2015.

Keep informed by visiting bebras.uk

Contents

Participating Countries

Each problem in this booklet has a flag indicating the country of origin. However, many people were involved in the further editiing, translating and providing additional material.
The UK team are indebted to the generosity of spirit and community of Computer Scientists around the world!

🍁 Funny windows

Kits: A Intermediates: A
Castors: A Seniors:
Juniors: A Elite:

The windows of a boat are either clear or lightly tinted.

Standing beside the boat you can look through two opposite windows at once. Depending on the colours of both windows they will appear to have a new colour:
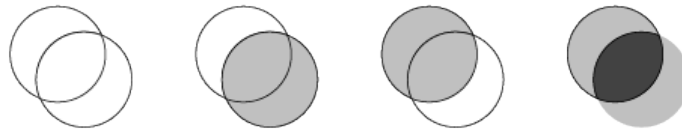
Captain Krysta has given you drawings of her boat showing which windows are clear and which are lightly tinted:
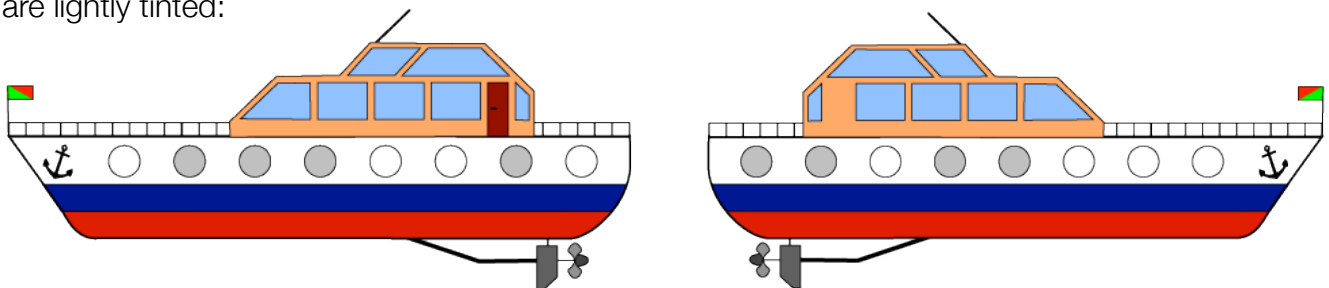
Click on the windows of the boat below to show what you would see if you stood beside it and looked through opposite windows.

Save Answer

Erase

Answer:

Explanation:

We have to first map corresponding windows on the two sides of the yacht by using the anchor as the reference point. Then when we see through two windows, the result is shown in the overlap. Another way of looking at it is:
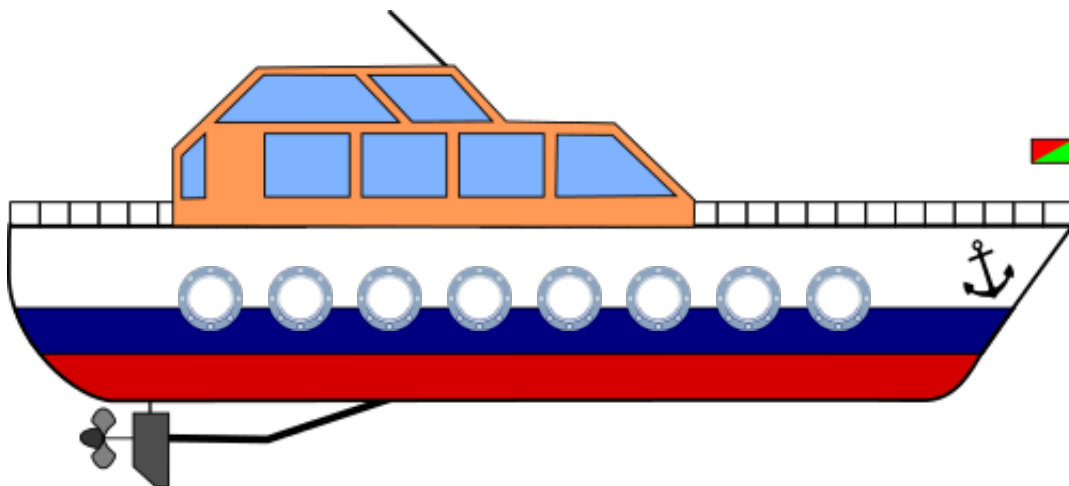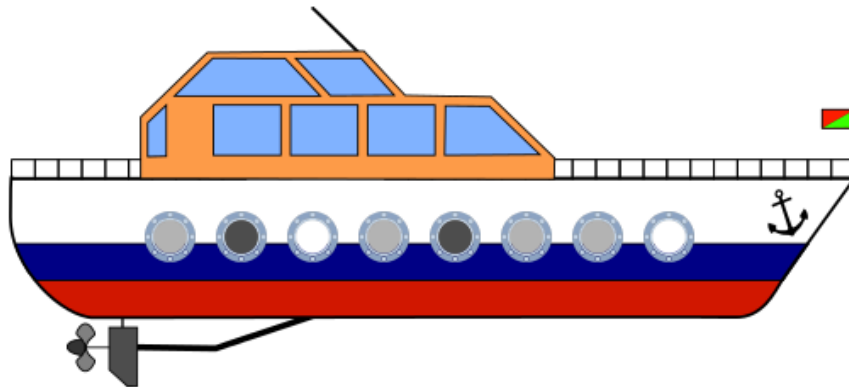
If the clear glass corresponds to 0 and slightly tinted glass as 1, and dark glass as 2.

This problem is simply solved by addition:

0 1 0 0 1 1 1 0
1 1 0 1 1 0 0 0 +
1 2 0 1 2 1 1 0

It's Computational Thinking:

Concepts - Abstraction (AB), Evaluation (EV), Generalisation (GE)

We think of all computer and digital data as a sequence of 0s and 1s called binary digits. At the root of any computation are operators that consist of two binary digits and produce more data. If we equate clear glass to 0 and any tinted glass (both light and dark) to 1, then the above operation corresponds to the OR operator. If we equate clear and darkly tinted squares to 0 and lightly tinted squares to 1, then the above operation corresponds to the XOR operator.

Ice cream

At the LIFO ice cream parlour the scoops of ice cream are stacked on your cone in the exact order in which you ask for them.

What do you have to say in order to get the ice cream shown in the picture?

I would like to get an ice cream with ...

... Chocolate, Smurf and Strawberry!

... Strawberry, Smurf and Chocolate!

... Chocolate, Strawberry and Smurf!

... Strawberry, Chocolate and Smurf!

Chocolate

Smurf

Strawberry

Answer:

... Strawberry, Smurf and Chocolate!

Explanation:

What is on top must be put there last! Similarly, the first flavour requested must be the first scoop on the cone. So we need to reverse the order:

To get a cone with Chocolate on top of Smurf both of which are on Strawberry we must ask for "an ice-cream with Strawberry, Smurf and Chocolate!"

It's Computational Thinking:

Concepts - Abstraction (AB), Generalisation (GE)

Order matters! If we asked for the flavours in a different order, we would have an entirely different ice cream cone.

One of the first things computer scientists learn is how important it is to have everything correctly ordered. They also need to understand how others understand. Without knowing exactly how the ice-cream shop works, we could not determine the correct order! We had to imagine first what will happen based on what we say. Just like computer scientists, who like to think ahead. The actual order used in this task is stack order. In particular "Last in, First out" or LIFO.

Magical bracelet
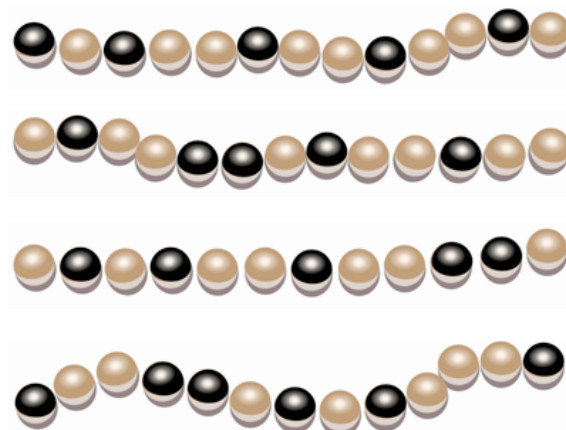
A princess has a magical bracelet that looks like this:
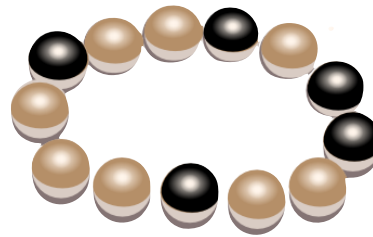
When she stores her bracelets in her drawer she first opens them.

Which of the four bracelets in her drawer is the magical one ?

Answer:

Explanation:
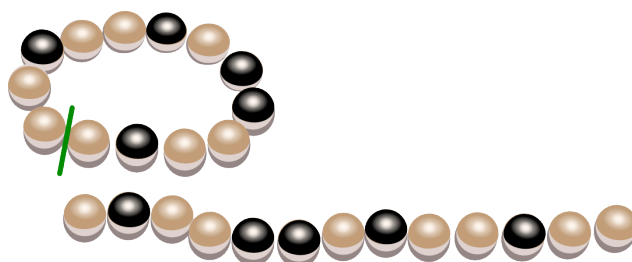
It's Computational Thinking:

Concepts - Decomposition (DE), Generalisation (GE)

The bracelet is an example of a sequence of objects. The pearls are arranged in a certain pattern. When identifying the correct bracelet you have to look for properties of this pattern.

In Computational Thinking, pattern matching means finding similar objects in different sources. In image processing, the pattern matching is used for locating a small image in a bigger one. Another example is searching for a word in text using a text processor.

Only nine keys

Kits:
Castors: A
Juniors: A

Intermediates: A
Seniors:
Elite:

Daniel is sending text messages from his old phone.

For every letter he has to press the proper key once, twice, three or four times, followed by a short pause.

In order to type 'C' he has to press the number 2 key three times because 'C' is the third letter written on this key.

In order to type 'HIM' he has to press the number 4 key twice, followed by the number 4 key 3 times and finally the number 6 key once.

Daniel presses exactly six times to enter the name of a friend.

What is the name of his friend?

Miriam

Iris

Emma

Ina

Answer:

Ina

Explanation:

MIRIAM requires 12 taps: M=1, I=3, R=3, I=3, A=1, M=1.

IRIS requires 13 taps: I=3, R=3, I=3, S=4.

EMMA requires 5 taps: E=2, M=1, M=1, A=1.

INA requires 6 taps: I=3, N=2, A=1.

So INA is the correct name.

### It's Computational Thinking:

Concepts - Algorithmic Thinking (AL), Decomposition (DE)

On a small keyboard with only nine keys you select a letter by tapping on a certain key several times quickly and then wait a short while. This is a special way to encode letters. Interface designers need to invent encodings like this, when they design user interfaces for input devices with limited abilities.

🇸🇮 Watering

The diagram shows how a watering system is connected. The system consists of tubes and valves. Open and closed valves are shown in the diagram by the direction of the switch.
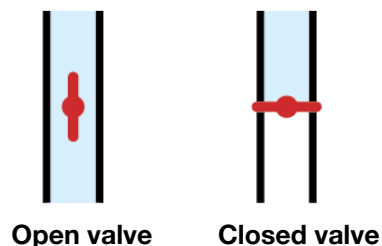
Water only flows through open valves

Open valve   **Closed valve**

Which of the flowers (if any) will receive water when the valves are in the positions shown below.
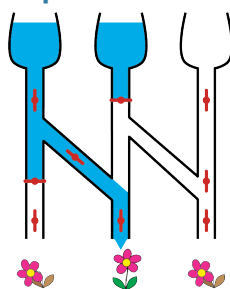
Click on the flowers that will receive water so that they look bright and fresh. Leave the flowers that will not get any water looking wilted.
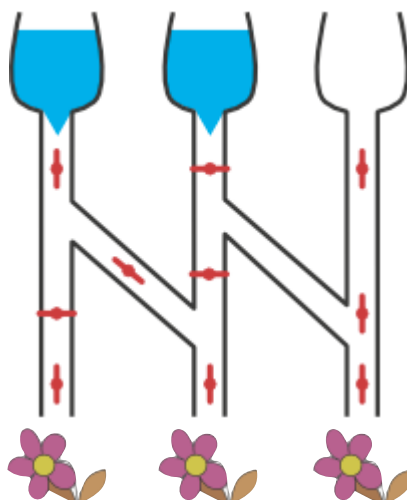
Answer:

Only the second flower.

Explanation:

It's Computational Thinking:

Concepts - Algorithmic Thinking (AL)

Computers are composed of various chips which are made of even smaller parts: electronic circuits. Electronic circuits are in turn composed of logic gates.

Logic gates act like valves, except that instead of water they conduct electricity and instead of pipes they have wires. This means that our modern electronic devices (including complex ones like computers and smartphones) are built up from simple logical operations.

🇧🇪 **Tic tac toe**

Kits:
Castors: A
Juniors: B

Intermediates:
Seniors:
Elite:

You are playing a game of tic-tac-toe with your friend. First your friend has to place an 'O', then you place your 'X'. You continue taking turns in this way. The player who places their three marks in a horizontal, vertical or diagonal line wins.

It is your turn to put an 'X' in the grid below:

Click on the grid to place your 'X' so that you have the best chance of winning.
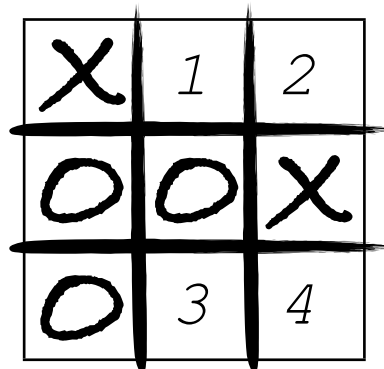
Answer:

Position 2

Explanation:

If you put the cross in 1st, 3rd or 4th position, your friend will have the possibility to put a circle in the 2nd position, which will lead to their victory.

However, if you put a cross in 2nd position, two possible alignments of crosses will be possible (by putting one in 1st position or one in 4th position). If your friend puts their circle in 1st position, you can put the cross in 4th and win; if your friend puts their circle in 4th position, you can put the cross in 1st and win; if your friend puts its circle in 3rd position you will win no matter where you put the cross.

The only way of being sure of a possible win is by putting the cross in position 2. However you are not guaranteed to win as there will still be a very silly move available to you which ends in a draw.

It's Computational Thinking:

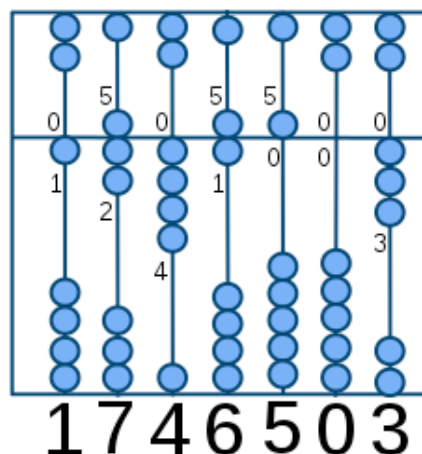*Concepts - Abstraction (AB), Algorithmic Thinking (AL)*

In the artificial intelligence domain, it is often necessary to explore a "states space", all the numerous ways to perform actions. From a current state, the strategy is to find the succession of states which will lead to the goal. The program has then to consider several states in advance, in order to make the right choice in the current state.

A number is represented on a Chinese abacus by the position of its beads.

The value of a bead on the top part is 5; the value of a bead on the bottom part is 1. The abacus is reset to zero by pushing the beads away from the centre.

To represent the number 1 746 503 the appropriate beads are moved towards the centre of the abacus:

1 7 4 6 5 0 3

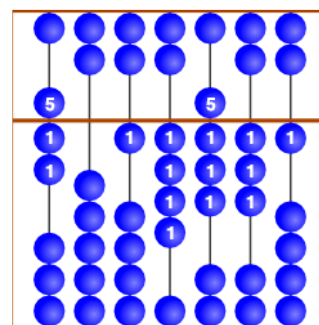## What number does the following abacus represent?
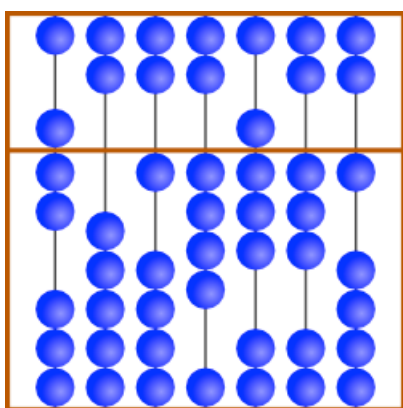
Answer:

7014831

Explanation:

By adding the values of the beads that are nearest to the centre of the abacus the answer shown can be obtained

7 0 1 4 8 3 1

It's Computational Thinking:

Concepts - Abstraction(AB), Decomposition(DE), Algorithmic Thinking(AL)

Since ancient times, the abacus has been a calculating tool that represents numbers with the help of stones or beads (the numbers are encoded). By moving the beads, you can compute numbers (addition, multiplication, etc.). Finally, the calculation result is read from the abacus (output).

The abacus is therefore a forerunner of the computer, as the computer encodes data, does computation, and outputs results.

For this task we used the chinese abacus "Suanpan" which is still commonly used in Asian countries. "Zhusuan", the traditional calculation method with the "Suanpan" was included in the "Representative List of the Intangible Cultural Heritage of Humanity" by UNESCO in 2013.

Select a picture

Kits: B
Castors: B
Juniors: B
Intermediates: A
Seniors:
Elite:

Johnny has 8 photos. He wants to give one to Bella.

He asks Bella three questions to help him select the best picture.

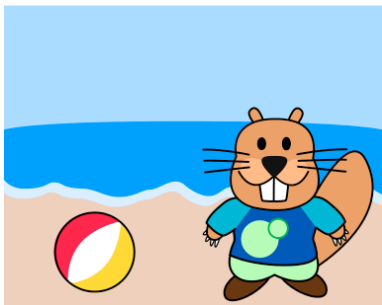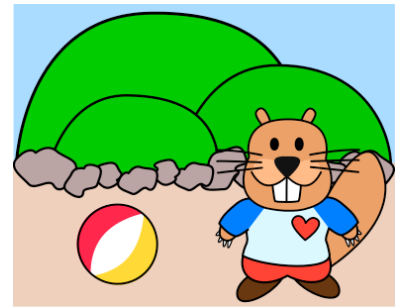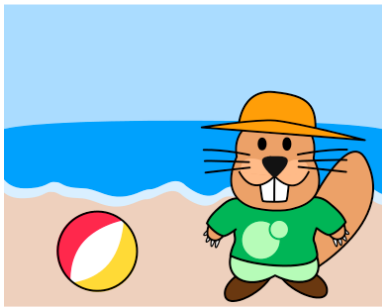| Johnny's Question	Bella's Answer
Do you want a photo with a beach umbrella?	Yes
Do you want a photo where I wear something on my head?	No
Do you want a photo where you can see the sea?	Yes

Which photo should Johnny give to Bella?

Answer:

Explanation:

Photos 2, 5, 6, and 8 satisfy the condition specified by Bella's answer to the first question.

Photos 3, 4, 6, and 8 satisfy the condition specified by Bella's answer to the second question.

Photos 1, 2, 4, and 6 satisfy the condition specified by Bella's answer to the third question.

The photo which satisfies all conditions is photo 6.

**It's Computational Thinking:**

Concepts - Algorithmic Thinking (AL), Decomposition (DE)

The problem is related to representing information using bits. In this example each image is represented by exactly three bits of information, corresponding to the three questions Johnny asks. Bella's answers are "yes" and "no" only. Yes and no, true or false, on or off, 0 or 1 – computers operate with only two different values. The power of computing is achieved by combining these bits logically. By her answers, Bella decides that the first bit is "on" AND the second bit is NOT "on" ("off") AND the third bit is "on".

With AND and NOT, bits can be combined in all imaginable ways. Any combination of answers to these questions selects a single photo. Everything that computers can do is achieved with just these simple logical operations on bits. Here, they are used for retrieving data (a photo) from a database (Johnny's photos).

Toothbrushes

It is time for bed! Every beaver should have a toothbrush that matches their size. But look at the picture to see what has happened.

Ann   Ben   Chad   Dan   Eve
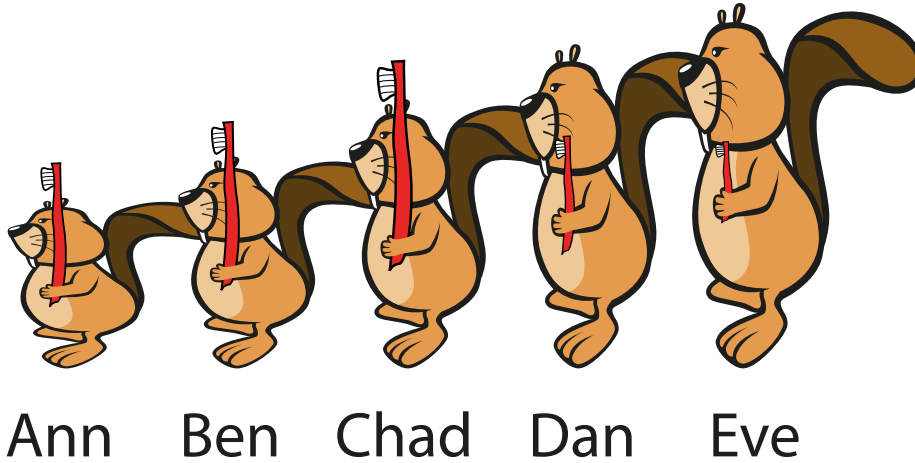
"Not so fast!" sighs mother beaver. "Eve and Chad, swap your brushes! Ann and Chad, you too!" But then she does not know how to continue.

Which two beavers still need to swap their toothbrushes so that all the beavers have the correct brushes?

Ben and Chad
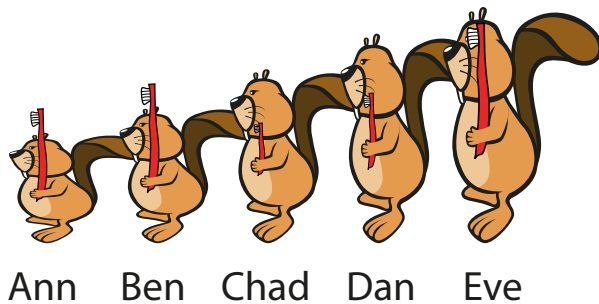
Ann and Eve

Ben and Dan

Nobody

Answer:

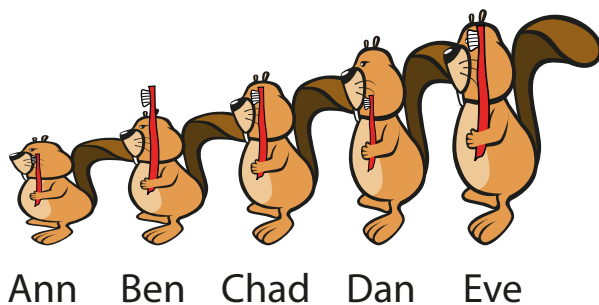Ben and Dan

Explanation:

After "Eve and Chad, swap your brushes!":

Ann   Ben   Chad   Dan   Eve

After "Eve and Chad, swap your brushes!":

Ann   Ben   Chad   Dan   Eve

All that remains is to swap Ben and Dan's brushes.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE)

Computer programmers are often like Mums, except that instead of ordering beaver children to swap brushes, they move numbers through different cells in the computer memory.

For instance, often there are some numbers we need to sort (like the size of the brushes). These numbers are stored in a group of memory cells. Sorting them consists of putting the smallest number in the first cell, the second smallest in the second cell, and so on, until the biggest number in the last cell.

To do that we need to exchange the values contained in these cells several times.

● village network

Kits:
Castors:
Juniors: B

Intermediates: A
Seniors: A
Elite:

A village is receiving a new wireless network consisting of several network towers. The network will offer WiFi to all the villagers.

Every network tower has the coverage area shown below. The red star represents the network tower. Only in the twelve shaded squares surrounding the tower will a house get a WiFi signal.
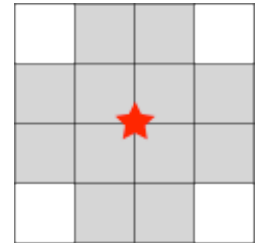
The picture below shows a map of the village divided into squares. Every triangle ▲ represents a house. A network tower cannot be built inside a square, only on the cross point of the village squares. The coverage areas may overlap.

What is the minimum number of network towers required to provide coverage to every house?
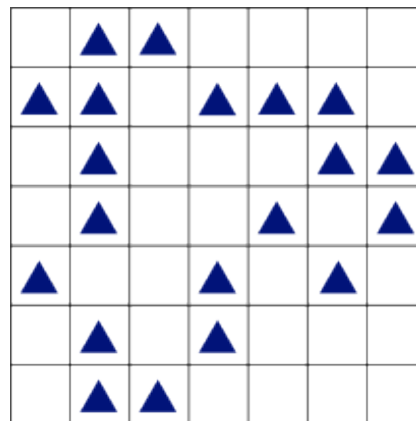
Answer:

3

Explanation:

You can not cover all of houses with two speakers.

Either of the following two arrangements of three speakers covers all of houses.
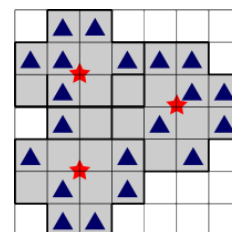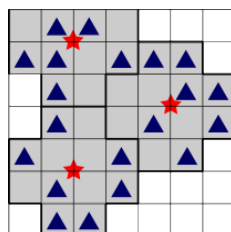
It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE)

Similar to dividing space into a number of regions, covering space with figures is applied to various uses in Computer Science. For example, enabling mobile communication base stations to efficiently cover wide areas.

Clinging robot

Kits:
Castors: C
Juniors: C

Intermediates: B
Seniors:
Elite:

The clinging robot walks along the road, always clinging to one side of the road. The clinging robot knows four commands:

Command	Explanation
START	Start walking along the side where you are standing
CONTINUE	Keep walking along the side where you are walking
SWITCH	Switch to the other side of the road and keep walking
STOP	Stop walking

A command is executed when setting off and whenever the robot walks across one of the grey magnetic devices on the road. All these devices are indicated on the map.

The clinging robot is given the following instruction set:

START SWITCH CONTINUE CONTINUE CONTINUE STOP

The robot starts as indicated in the picture. Click on the grey spiky circle where the robot stops.
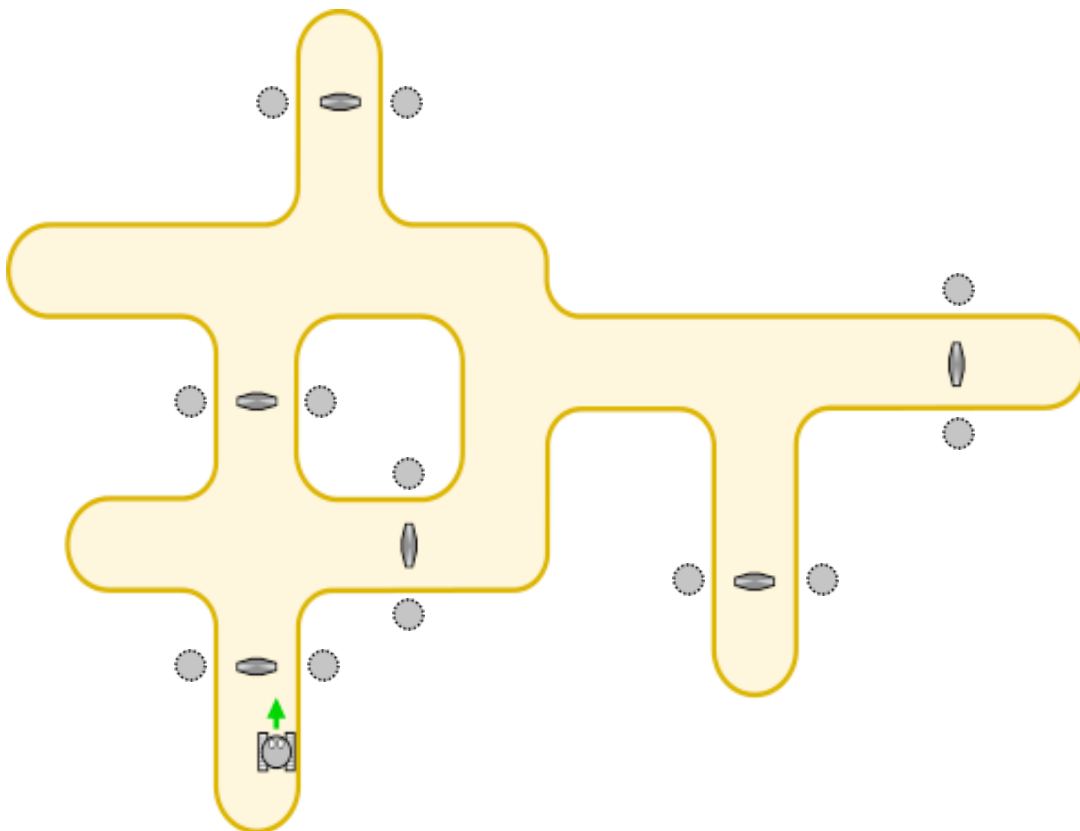
Answer and Explanation:
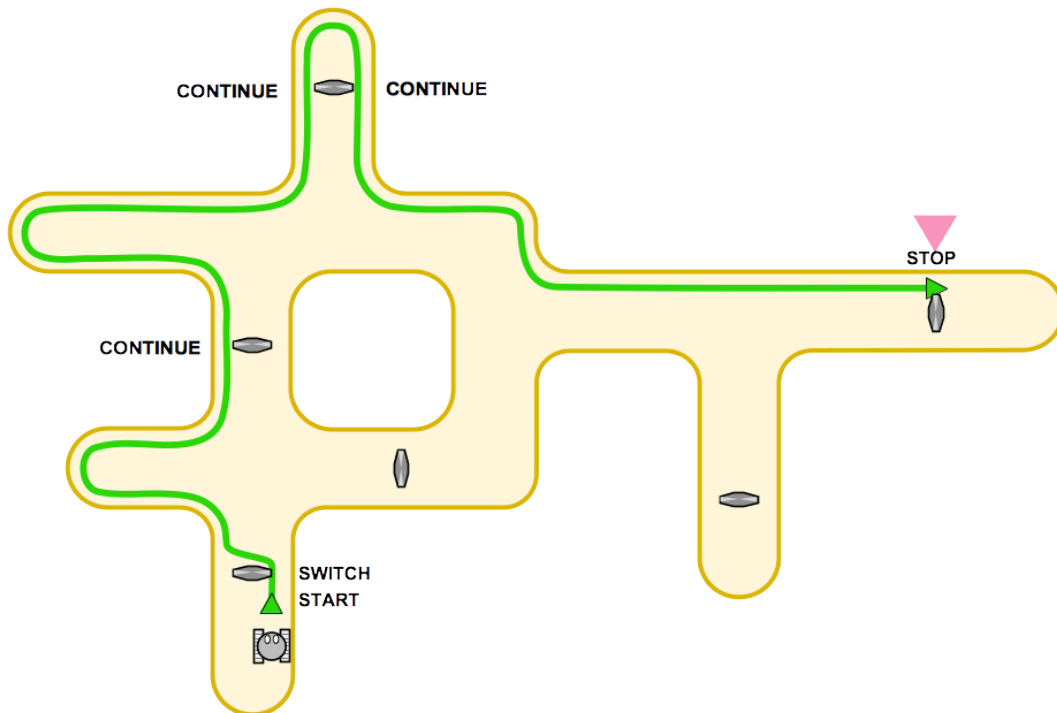
It's Computational Thinking:

Concepts - Algorithmic Thinking (AL), Evaluation (EV)
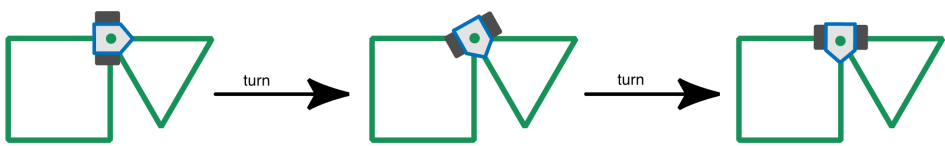
Automatically moving vehicles are found in many places including tunnel systems, airports and factories. These machines are controlled by computer programs. Basically a computer program is a sequence of commands. The commands are related to physical sensors and provide the "intelligence" required by the vehicles to navigate their limited environment.

Drawbot

The robot 'Drawbot' can drive and draw at the same time!

You can give the drawbot the following instructions: square, triangle, forward, turn.
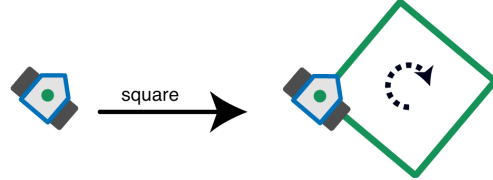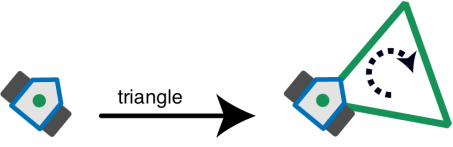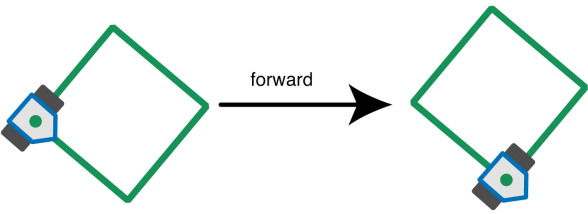
The instructions work as follows:

square: Drawbot draws a square. At every corner he turns right.	
triangle: Drawbot draws a triangle. At every corner he turns right.	
forward: Drawbot drives forward on a line that has been drawn until the next corner.	
turn: Drawbot turns to the right until the next drawn line.	

You can also give a sequence of commands to drawbot:

For instance: **square, forward, triangle**

The image on the right shows what will happen.
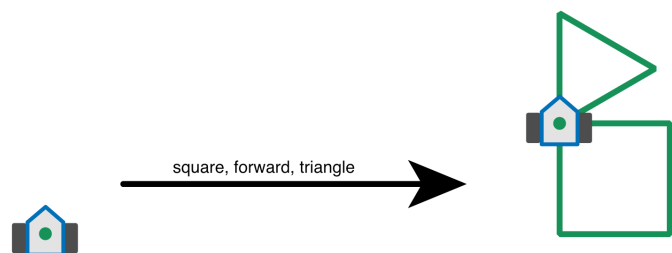
Which sequence of instructions causes this to happen?

square, turn, forward, triangle

triangle, turn, square

triangle, turn, forward, square

square, forward, square, turn, triangle

22
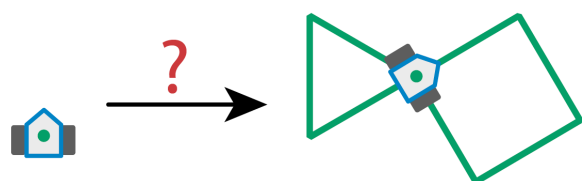
Answer:

triangle, turn, forward, square

Explanation:

The answer can be worked out by spotting the obvious mistakes, like drawing multiple squares, or by following the commands and drawing the pictures.

   square, turn, forward, triangle – draws a triangle in the wrong place.

   triangle, turn, square – draws a square on top of the triangle.

   square, forward, square, turn, triangle – paints two squares.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE)

Programs that we use on our computers consist of sequences of commands, just like those we have seen here.

The task is inspired by "turtle graphics", which is often used for teaching programming. It was introduced as part of Logo, one of the first languages for children. Today you can try it out in a more modern environment called Scratch or as a module in Python.

Websites:

https://en.wikipedia.org/wiki/Turtle_graphics
https://en.wikipedia.org/wiki/Logo_(programming_language)

http://scratch.mit.edu/

https://docs.python.org/3.4/library/turtle.html

Loading Lisas

Two fishermen own two boats, named "Lisa 1" and "Lisa 2". Each boat can hold a maximum cargo of 300kg.
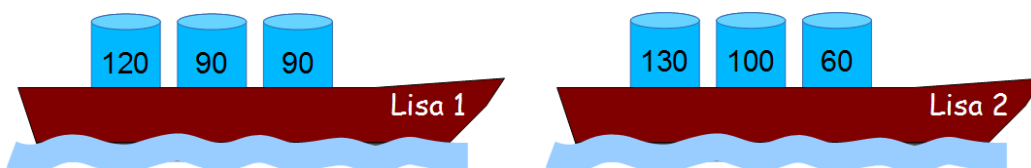
The fishermen are given barrels filled with fish to transport. On each barrel is a number that shows how heavy the barrel is in kilograms.

You must make sure that neither boat is overloaded.

Drag barrels onto the two boats so that the maximum possible load of fish is carried.

| 220 | 130 | 120 | 100 | 90 | 90 | 60 |

Lisa 1   Lisa 2

Answer:

Lisa 1: 120 90 90

Lisa 2: 130 100 60

Explanation:

It is possible to get the boats loaded with 590 kilos:
20+90+90=300 kilos on one boat, 130+100+60=290 kilos on the other.

Do not be greedy! If you try to load heavy barrels first, you will end up at 220+60=280 kilos and 130+120=250 kilos which is only 530 kilos total.

Also, we cannot do more than 590. Indeed, if we want to do more, we have to fill both boats with 300kg. But there is only one way to make 300: 120+90+90.

It's Computational Thinking:

Concepts - Decomposition (DE), Evaluation (EV)

In many areas of life, people like to optimise things – typically in order to maximise their profit. Computers are often used for optimisation: for finding the shortest route, for determining optimal loads like in this task, and so on. In some optimisation tasks, it can be sufficient to use a "greedy" approach: to take the most profitable step next. But in most interesting applications, greediness fails and does not deliver optimal solutions. More complex algorithms have to be used. Unfortunately, for many optimisation tasks it is only possible for Computer Scientists to develop algorithms to find close-to-optimal solutions.

🇫🇷 Monster

Kits:
Castors:
Juniors: C

Intermediates: B
Seniors: A
Elite:

In the basement of a castle lives a monster. The monster is hiding in one of the yellow rooms. The monster can only stay in yellow rooms.

You want to catch the monster. Click on any yellow room. This will reduce the total number of yellow rooms by half. Click again on another yellow room, etc.

When there is only one yellow room left you have caught the monster.

Find the lowest number of rooms you need to click to trap the monster.
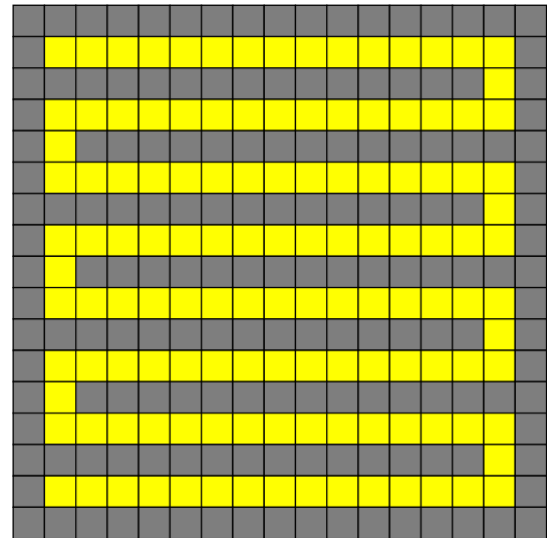
Save the lowest number of clicks required as your answer.

Answer:

6

Explanation:

To solve this task and get a good score, it was necessary to find a good strategy, or algorithm. The best strategy here was to perform a binary search: at each step, divide the remaining space available to the monster by two, by placing a block right in the middle. There were 127 cells in the initial space available, that formed a path. By blocking the 64th cell of that path, we end up with two paths of length 63, one of which contains the monster. We can again divide the remaining space by two and get two blocks of 31 cells, then 15, 7, 3, and finally 1. This gives the minimum number of blocks required as 6.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE)

The binary search algorithm is one of the most well known and useful algorithms. This algorithm used to be applied by many people when searching for a word in a dictionary or a name in a phone-book, when dictionary and phone-books were made of paper and were not just apps. This task gave you the opportunity to rediscover this algorithm by yourself and to understand why it works.
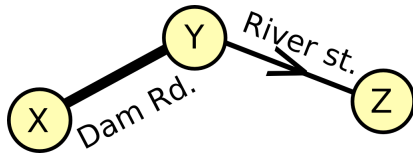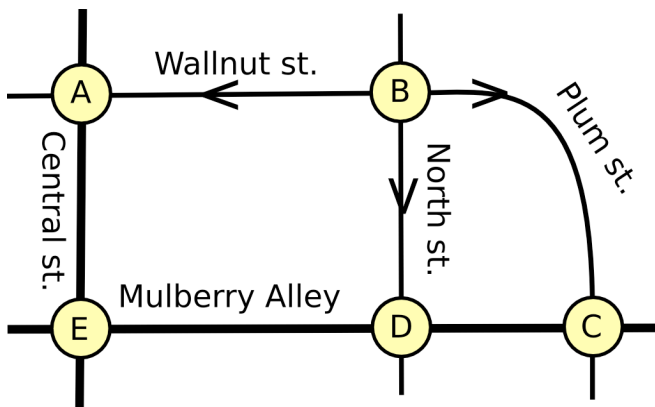
Traffic in the city

In a small village there is a one-way street and a two-way street. In order to help the village taxi driver a table is made to show which routes can be taken. Below is the map and the corresponding table.

		To		
From		**X**	**Y**	**Z**
	X		✓	
	Y	✓		✓
	Z			

Beaversville is a little larger and also wishes to have a table for its taxi drivers:

Fill in the table for the taxi drivers.

	A	B	C	D	E
A					
B					
C					
D					
E					

Answer:

	A	B	C	D	E
A					✓
B	✓		✓	✓	
C				✓	
D			✓		✓
E	✓			✓	

Explanation:

Remember you can only place a tick if the taxis can travel from the letter on the left to the letter at the top. For this to be possible there must be either an arrow facing in the correct direction or a line representing a two-way road between the two letters.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL)

The table is known as an adjacency matrix. The table ignores the length and shape of all the streets and allows us to focus on whether or not there is a way to travel directly between two given intersections. So the table is an abstract model which ignores information that is not important to us. It is now much easier to store this information in a computer and more efficient to look up this information.

🇸🇮 Space maze

Some space explorers landed on an empty planet. From their ship they could see a maze with an unknown golden object in it.

The explorers dropped their robot into the maze hoping it could take a closer look at the unknown object. Unfortunately the robot broke during the fall and can now only send and receive garbled instruction about where to go.
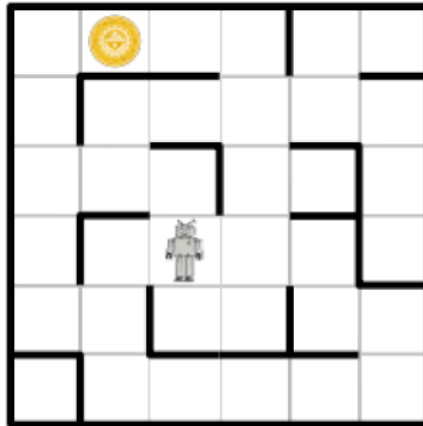
The robot suggests four possible directions it can go. Even though the words in the instructions are garbled, there are still only four different words, each indicating north, west, east or south. When following the instructions the robot will move into an adjacent square as instructed.

Which instructions should the explorers send the robot in order for it to reach the golden object?

A. Ha' poS poS Ha' Ha' nIH

B. Ha' poS poS Ha' nIH Ha'

C. Ha' Ha' poS Ha'

D. Ha' poS nIH vl'ogh Ha' poS

Answer:

A.   Ha' poS poS Ha' Ha' nIH

Explanation:

Ha' is Up, vl'ogh is Down, poS is Left, and nIH is Right.

Sequence C is too short: it is impossible to reach the artefact in fewer than six steps.

Sequence B must be wrong. If Ha' means West, then poS must be South – and the robot bumps into the wall at the third move; besides, it would go in the wrong direction anyway. If Ha' is East, then poS must be North, but the robot strays away in the fourth move.

The first four steps of sequence D move the robot in each direction once (in an unknown order), thus after the first four commands the robot is back where it started. It cannot reach the artefact in the remaining two steps.

It's Computational Thinking:

Concepts - Algorithmic Thinking (AL)

Cryptanalysis is the science of reading hidden messages. From ancient times, experts called cryptanalysts have been trying to decipher messages sent by enemies. In doing so, they may also use their knowledge about the words that may possibly constitute the hidden message. For instance, in reading the messages enciphered by the famous Enigma machine in the 2nd World War, the English searched for names of German cities and words related to weather reports.

In this task, you were working like a cryptanalyst, except that the message was not hidden by intent: you helped to read an ancient text in the language that nobody understands any more. This task was of course much simpler if you happen to speak Klingon.

Websites:

https://en.wikipedia.org/wiki/Cryptanalysis

https://en.wikipedia.org/wiki/Cryptanalysis_of_the_Enigma#Crib-based_decryption

https://en.wikipedia.org/wiki/Klingon_language

● Mobile phones

Kits:
Castors:
Juniors: C

Intermediates: C
Seniors: B
Elite:

The beaver family have three mobile phones but none of the batteries have any charge.
It takes 1 hour to fully charge a mobile phone but this does not need to be done all in one go.
The beaver family only have two mobile phone chargers in the house.

What is the shortest time they need to fully recharge the three phones?

3 hours

2 hours

1 hour and a half

1 hour

Answer:

1 hour and a half

Explanation:

The charging can be achieved in the following way:

1. charge mobile 1 + 2 for half an hour.

2. charge mobile 1 + 3 for half an hour.

3. charge mobile 2 + 3 for half an hour.

Also, we cannot charge the phones in less than 1 hour and a half. Indeed, we need to cumulatively charge for three hours. We have two chargers, therefore we can only do it twice as fast at most, that is in 1 hour and a half.

It's Computational Thinking:

Concepts - Abstraction (AB), Decomposition (DE), Evaluation (EV)

This is a scheduling problem. Scheduling is used in computer science when tasks may be performed faster by dividing them among many CPUs: we choose which CPU will work on which task, when, and for how long. There are many different algorithms for scheduling. The most simple one is "first come, first served": you perform the tasks in the order they arrive. Here it would be to fully charge mobiles 1 and 2, and then charge mobile 3. But in this case this is not optimal. When we need to divide tasks, it is important to choose carefully the way we assign them, so as to optimise one particular objective (time of end for instance).

Scheduling is also used in disk drives (I/O scheduling), printers, net routers etc. Usually scheduling problems are very difficult problems. In many cases we do not know how to solve them efficiently or even if it is possible to solve them at all.

🇨🇦 Beavers on the run

A colony of beavers is travelling through a dark forest. The path is narrow, so they travel in a row without passing.

Sometimes there is a hole in the path. A hole is passed in the following manner:

- First as many beavers jump into the hole as fit in.
- The entire colony will then pass across the hole.
- The beavers that jumped in will then climb out.

The images on the right show how five beavers pass a small hole that fits three beavers.
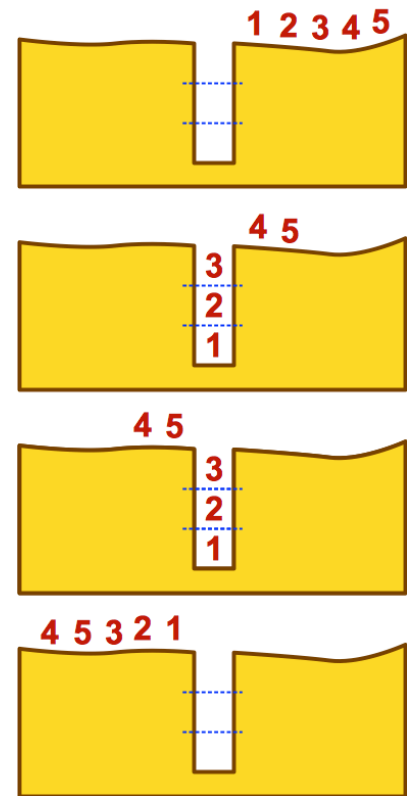
Question:

A colony of 7 beavers passed through the forest. They pass over 3 holes.
The first hole fits 4 beavers, the second fits 2, and in the last hole fit 3 beavers.
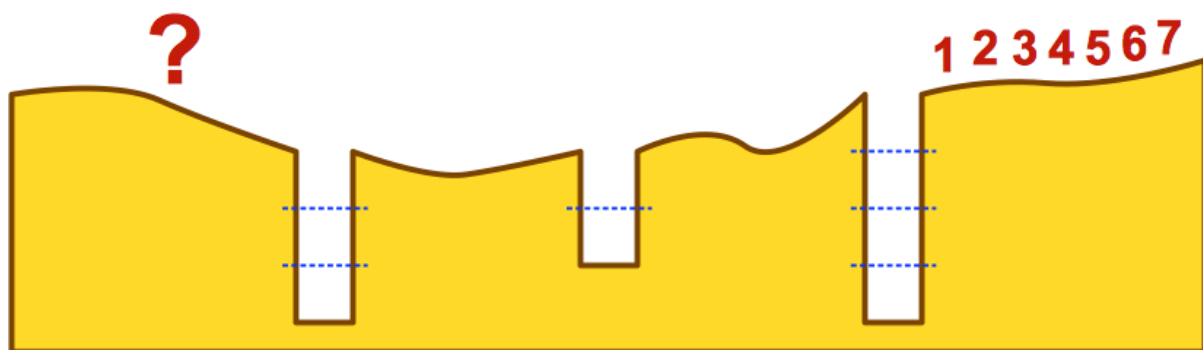
What order do the beavers find themselves after they have passed the third hole?

4756123

6574321

2165347

5761432

Answer:

2165347

Explanation:

Initially the line is 1 2 3 4 5 6 7

Then after the first hole of depth 4 we have:

5 6 7 4 3 2 1

After the second hole (depth 2) we have:

7 4 3 2 1 6 5

After the third hole (depth 3) we get:

2 1 6 5 3 4 7

It's Computational Thinking:

*Concepts - Abstraction(AB), Decomposition(DE), Algorithmic Thinking(AL)*

Organising data in a structured way is important in computer science and there are many different data structures that can be used for this purpose.

This task shows an example of a structure called a stack, which works similarly to stacking plates on top of each other. You always add new plates on top of the stack and have to remove them from the top one at a time. This type of structure is commonly referred to as a LIFO-structure – the objects that have been added last are the first to be removed. (LIFO = Last In First Out)

Organizing a festive day is a lot of work in Bebras City. All the events must occur in a specific order.

The diagram shows all the events that must be included. The arrows indicate that an event has to occur before another event. For example, the Musical Intermezzo can only happen after both the Drum Roffle and the Boring Speeches have finished.
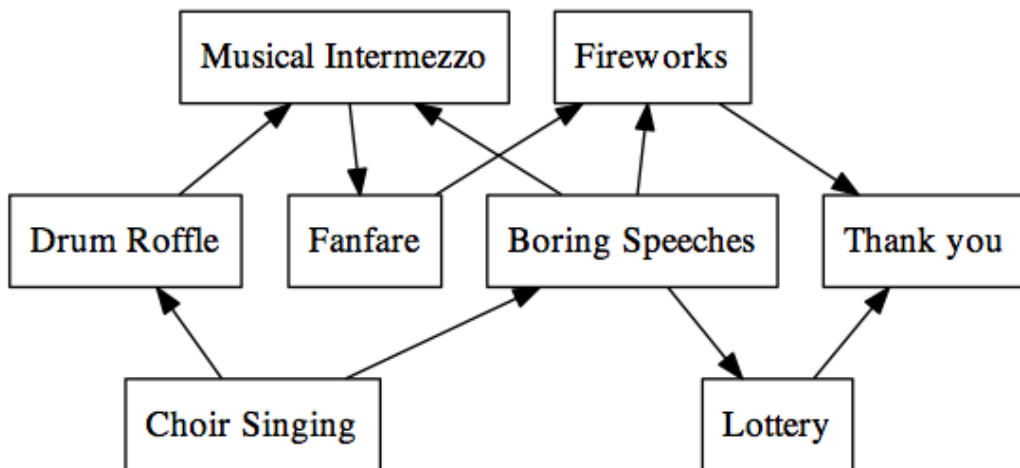
Rearrange the events of the day in the box below.
Drag them into an order that follows the rules shown in the diagram.

Fireworks

Lottery

Thank you

Boring Speeches

Drum Roffle

Choir Singing

Fanfare

Musical Intermezzo

Save Answer

Erase

Answer:

Choir Singing

Drum Roffle

Boring Speeches

Musical Intermezzo

Fanfare

Lottery

Fireworks

Thank you

Explanation:

One way to obtain such an order is to follow the following algorithm:

While some events have not yet happened, find one such that every event pointing at it has already occurred. For example, at the beginning, "Choir Singing" is the only event that has no other event pointing at it, so it can proceed.

Then, since both "Boring Speeches" and "Drum Roffle" only had "Choir "Singing" pointing at them, and since "Choir Singing" has already happened, both of these can now take place. We can start with "Drum Roffle", for example. And so we can continue in this manner until we have our sequence.

There are several other valid answers, depending on which event is chosen first when there are options available in the algorithm.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL)

Solving this tasks means performing a topological sort of the graph. This means understanding the graph representation, as well as the precedence relationships.

Log-art

When beavers gnaw on trees they enjoy placing the pieces in a special way.

The beavers start with a single log. In stage one a big log is gnawed into smaller logs. In the next stage each individual log is again gnawed into even smaller logs but always keeping to the starting pattern. This keeps repeating.

Here are three examples. On each line you see how the beaver started, the result after stage one and the result after stage two.

		Stage 1	**Stage 2**
Example 1			
Example 2			
Example 3			

If the result of the second stage looks like this:
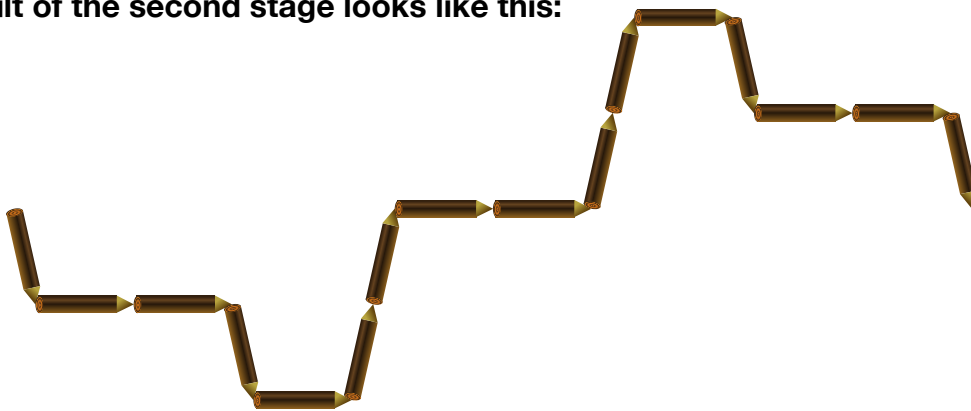
What was the first stage?

Answer:

Explanation:

Start	**Stage 1**	**Stage 2**
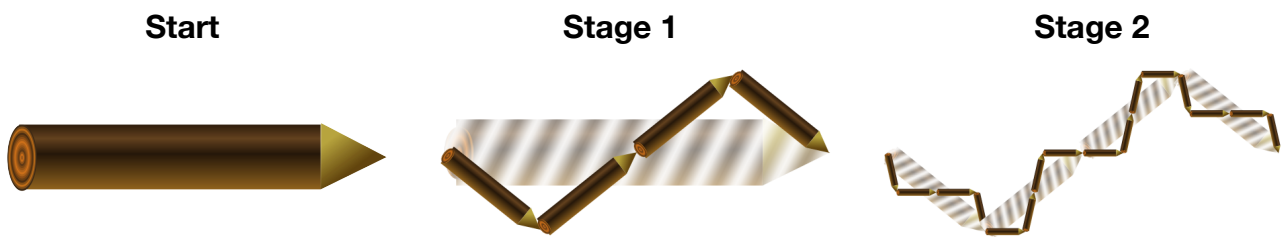
It's Computational Thinking:

Concepts - Abstraction (AB), Generalisation (GE)

Computer programs represent a set of rules that can be executed on a computer. Even very simple rules can lead to complex behaviour if applied repeatedly. In this task we present the construction rules of so-called fractals. Fractals are graphics with an infinitely self-similar structured shape. Even simple rules may result in stunningly beautiful graphics.

The first example shows the first 2 construction steps of Koch's snowflake curve.

🍁 Broken machines

Hans constructed three machines, which were all supposed to output the second largest value from a list of four numbers.

Machine 1	**Machine 2**	**Machine 3**
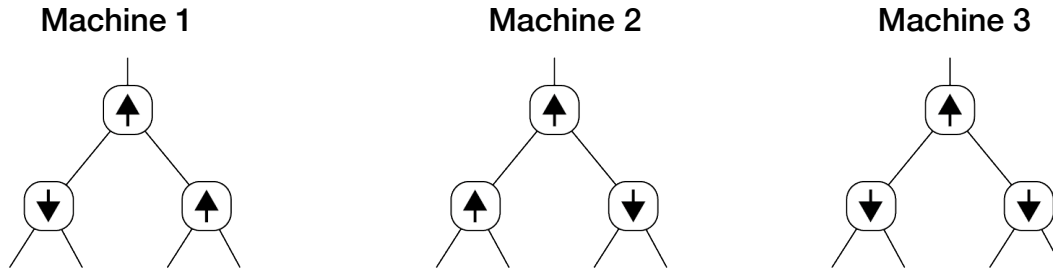
The machines can use two different components, called 'max' and 'min'.

'max' takes two numbers and outputs the largest

'min' takes two values and outputs the smallest

In other words, if numbers represented by a, b, c and d are input to a machine in this order, the results would be as follows:

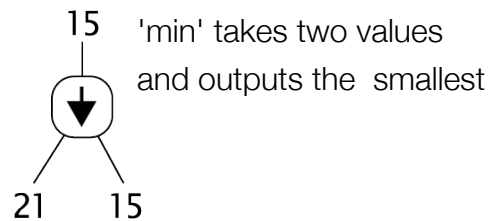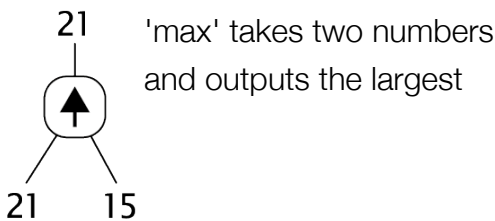Machine 1: outputs max(min(a,b), max(c,d))

Machine 2: outputs max(max(a,b), min(c,d))

Machine 3: outputs max(min(a,b), min(c,d))

For example, if Hilda inputs the numbers 4, 3, 2, 1 into Machine 1, the output she will get is 3, which is indeed the second largest value.

However, as she continued working with the devices she quite quickly realised that none of the machines actually work. In fact, she only needed to try two number combinations in order to discover this.
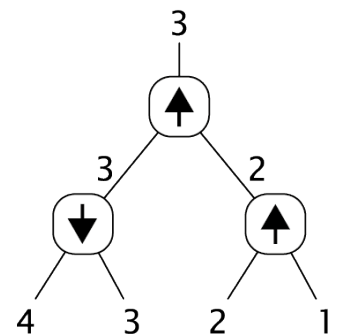
Which of the following combinations did she use to prove none of the machines work?

1, 2, 4, 3 and 2, 3, 4, 1

2, 1, 3, 4 and 2, 3, 4, 1

1, 4, 2, 3 and 2, 3, 4, 1

1, 4, 2, 3 and 4, 1, 2, 3

Answer:

1, 4, 2, 3 and 2, 3, 4, 1

Explanation:

It is possible to check that for each combination of values that appears in the answers, the result will be incorrect for at least one device:

Combination	Device 1	Device 2	Device 3
1,2,4,3	X (outputs 4)		
1,4,2,3		X (outputs 4)	X (outputs 2)
2,1,3,4	X (outputs 4)		
2,3,4,1	X (outputs 4)		X (outputs 2)
4,1,2,3		X (outputs 4)	X (outputs 2)

From the table, we can see that it is enough to try the combinations 1, 4, 2, 3 and 2, 3, 4, 1 as they show that none of the devices work.

Note that we could also use other pairs of these combinations to show that the three devices fail but of the choices given there was only one solution.

Can you find a single combination for which all three devices would fail?

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Evaluation (EV)

Software is critical in today's world. Computer programs are used to deliver medicine, move millions of dollars between accounts and control weather monitoring systems. A failure or a "bug" in a program can have catastrophic consequences. Therefore it is very important to test the programs carefully and systematically: we should act like prosecutors in a court-room trying to prove that the accused person is guilty, otherwise there is a high risk that our programs will not always work as expected.

As this task showed, it is not enough to only try a few values at random; you might get lucky and happen to test some exceptional data for which the system actually works. Rather, testing needs to be done in a structured and organised manner.

Websites:

http://en.wikipedia.org/wiki/Software_testing

http://listverse.com/2012/12/24/10-seriously-epic-computer-software-bugs/

Kits:
Castors:
Juniors:

Intermediates: C
Seniors: C
Elite: B

Storm proof network

On a small green island a network of mobile phone towers is setup. Every tower covers a circular area of the island.

When the coverage area of two towers overlaps the towers are said to be directly connected. Towers can also be indirectly connected if there is a chain of directly connected towers between the two towers.

Tower

Coverage area
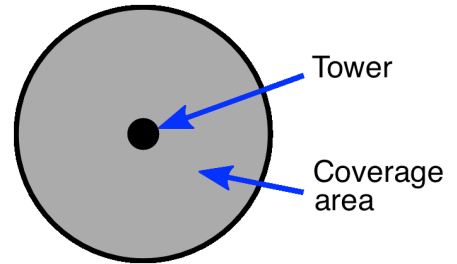
The operators want to make the network of towers Storm Proof. This means that even if one tower breaks down all other towers must still be connected, either directly or indirectly.

Which system shown below is a way to create a storm proof network on the island?
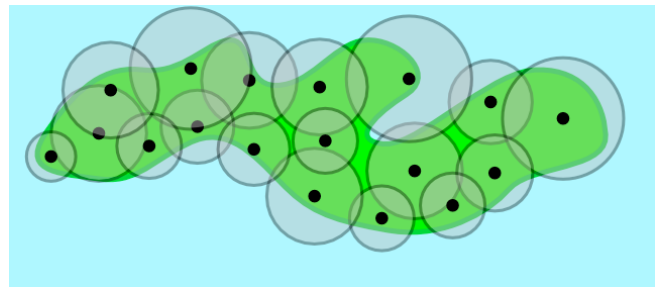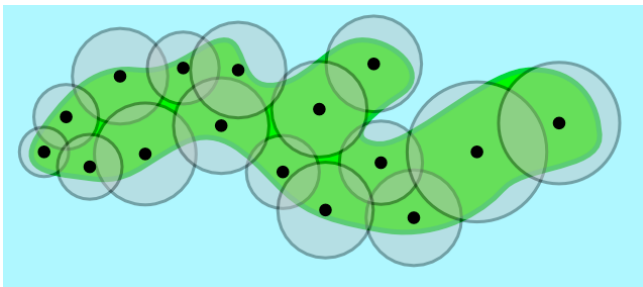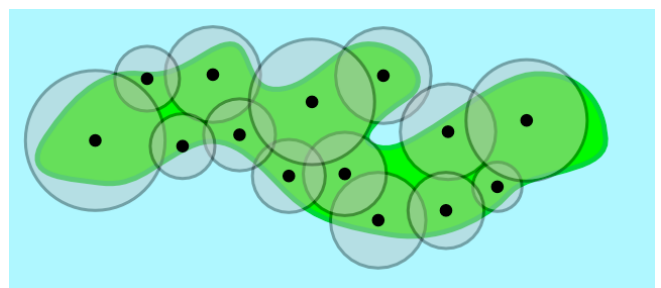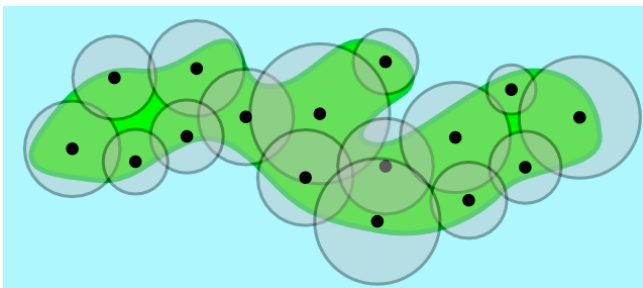
Answer:
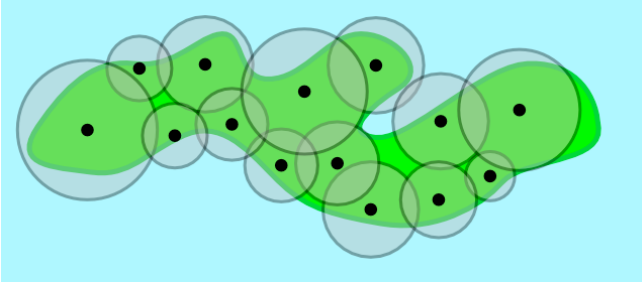
Explanation:

Following the coast, one can see that the towers are connected in a loop, if a tower breaks, a signal can still be sent between any two remaining towers.

In the other cases, there exists a tower that, if broken, will mean a signal cannot be sent between some pair of towers. One example in each case is highlighted in the pictures below. Insert images:
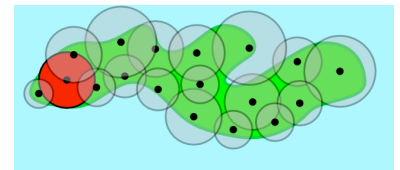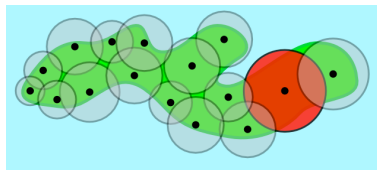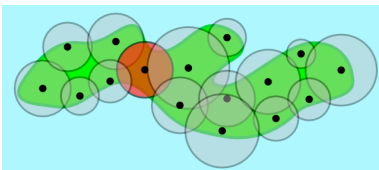
It's Computational Thinking:

Concepts - Abstraction (AB), Evaluation (EV), Generalisation (GE)

The placement of the towers (called vertices or nodes) and the way they are connected is called a graph or network topology. Industries need us to study these structures looking for designs that result in a system that is as reliable as possible. Similar structures can be physical or logical and they can take various shapes (e.g. ring, tree, mesh, etc.). We might then also ask other questions and evaluate properties related to different aspects of usability.

Note that, in reality the towers communicate via directed antennas and over different frequencies than mobile phones.

Footprints

Kits:
Castors:
Juniors:

Intermediates:
Seniors: C
Elite: B

The instructions for a **1-tree**:

Step forward 1 step to make one footprint, go back in your own

prints.

When you know how to make a 1-tree, you can learn how to make a **2-tree**:

Step forward 2 steps to make two footprints.

Turn left and make a 1-tree.

Turn right and make a 1-tree.

Go back in your own prints.

It is easy to explain how to create a **3-tree** because a 3-tree consists of 2-trees:

Step forward 3 steps to make three footprints.
Turn left and make a 2-tree.
Turn right and make a 2-tree.

Go back in your own prints.

In a similar way you can create a 4-tree.

Which of the following trees is a proper 4-tree?

Answer:

Explanation:

This tree is a 4-tree, made of 4 steps plus two 3-trees.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE)

The scheme is as compact as it is clever. It works for any imaginable size of a tree.

An X-tree is printed through X steps forward plus two (X-1)-trees. These are printed through X-1 steps forward plus two (X-2)-trees …

In Computational Thinking this is called recursion where a task is explained through a simpler version of the task itself. Finally, recursion puts the task down to a base task, like printing a 1-tree: to make an X-tree, you just have to remember the way to combine (X-1)-trees into it, and only remember how to do a 1-tree.

In practice, recursively defined algorithms can be very elegant. On the other hand, overuse of recursion can produce a confusing and inefficient algorithm.

This task is also an example of a recursive fractal which can produce beautiful output.

Website:

https://en.wikipedia.org/wiki/Recursion

✚ Puddle jumping

Kits:
Castors:
Juniors:

Intermediates:
Seniors: C
Elite: B

Anna (age 7), Bert (age 8), Carl (age 9), Dora (age 10) and Ella (age 11) are playing a game where they jump from puddle to puddle.

They have placed arrows between the puddles, and they all start on the left side as indicated.

When a child jumps into a puddle he or she waits for a second child to arrive. The oldest child will then jump following the thick arrow, the youngest, follows the narrow arrow.

Drag the names of the children to the right side of the field to show where each child ends.
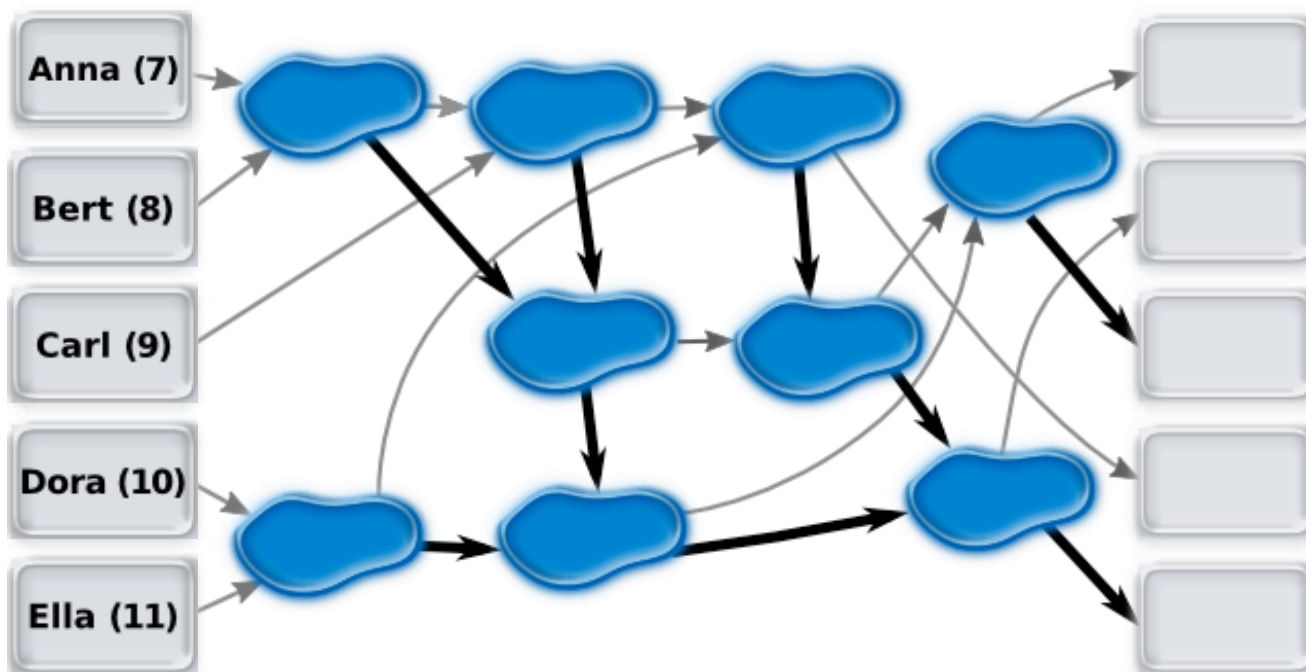
Answer:
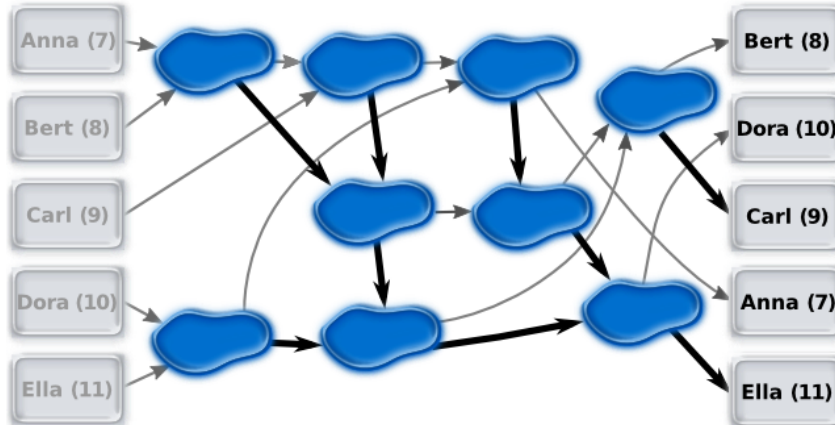
Explanation:

By using some colourful highlighters we can trace the movement of the children and the decisions made at each puddle:
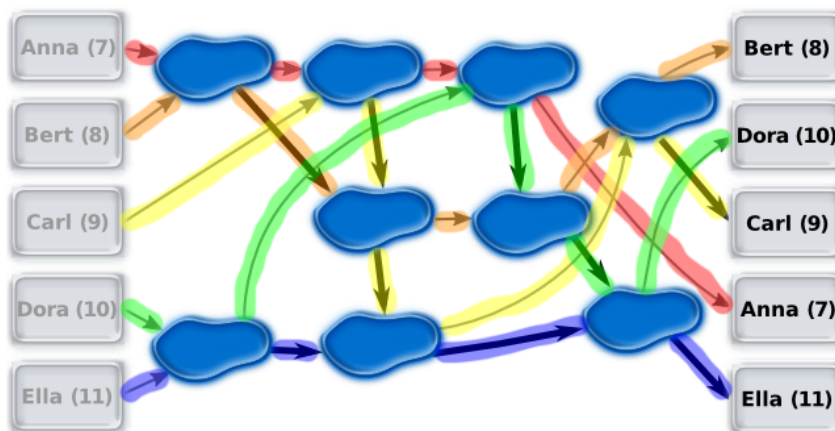
It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE)

Networks consist of wires and many comparators that compare the values of the two incoming wires and then output the smaller and the larger of different inputs. If this network has comparators that are interconnected in the right way, it can sort a sequence of unsorted values. Such a network is called a sorting network. These sorting networks work in parallel and can be very efficient at sorting.

In the example task, the network of puddles does not sort because the comparators are not connected in such a way. It just takes a given input sequence and outputs a different order.
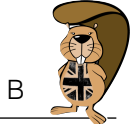
Both of the pictures show the same information about friendships between beavers that live in a lodge.
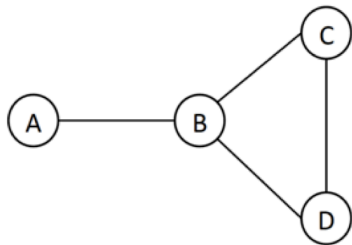
	A	B	C	D
A		O		
B	O		O	O
C		O		O
D		O	O	

For example, beaver A is only friends with beaver B (and beaver B is also friends with beaver A). If beaver A wishes to become friends with beaver C, he would need to get an introduction by Beaver B. The following diagram shows the friendships between 7 beavers.

	A	B	C	D	E	F	G
A		O	O	O			
B	O		O	O			
C	O	O		O			
D	O	O	O		O		
E				O		O	O
F					O		O
G					O	O	

What is the minimum number of introductions beaver A needs in order to become friends with beaver G?

1   2   3   or   4

Answer:

2

Explanation:

A needs two introductions at least, according to the friendship table:

	A	B	C	D	E	F	G
A		O	O	🟣			
B	O		O	O			
C	O	O		O			
D	O	O	O		O		
E				🔴		O	🟤
F					O		O
G					O	O	

or we can rebuild the social network as following:
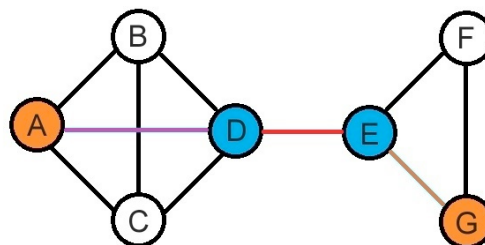
It's Computational Thinking:

Concepts - Algorithmic Thinking (AL), Evaluation (EV), Generalisation (GE)

A network (or graph) is a visual notation for a human. However, an adjacency matrix is used to represent a graph in a program. With this matrix, we can further apply all the algorithms from graph theory or manipulate the nodes and links in the graph, so the transformation between graph and adjacency matrix is an important concept for computer scientists.

Best translation

Aeysha is trying to translate an English sentence into an ancient language. Every word translates into a foreign symbol. There are several possible symbols for each word. Betty wants to find the best translation.

Under each English word Betty has written down the possible foreign symbols. Between each pair of symbols, she has indicated how well they fit together in that order. (A higher number means a better fit.)

The best translation would be the five symbols which produce the highest total maximum score. Betty has prepared the translation of 'our school serves fish today':
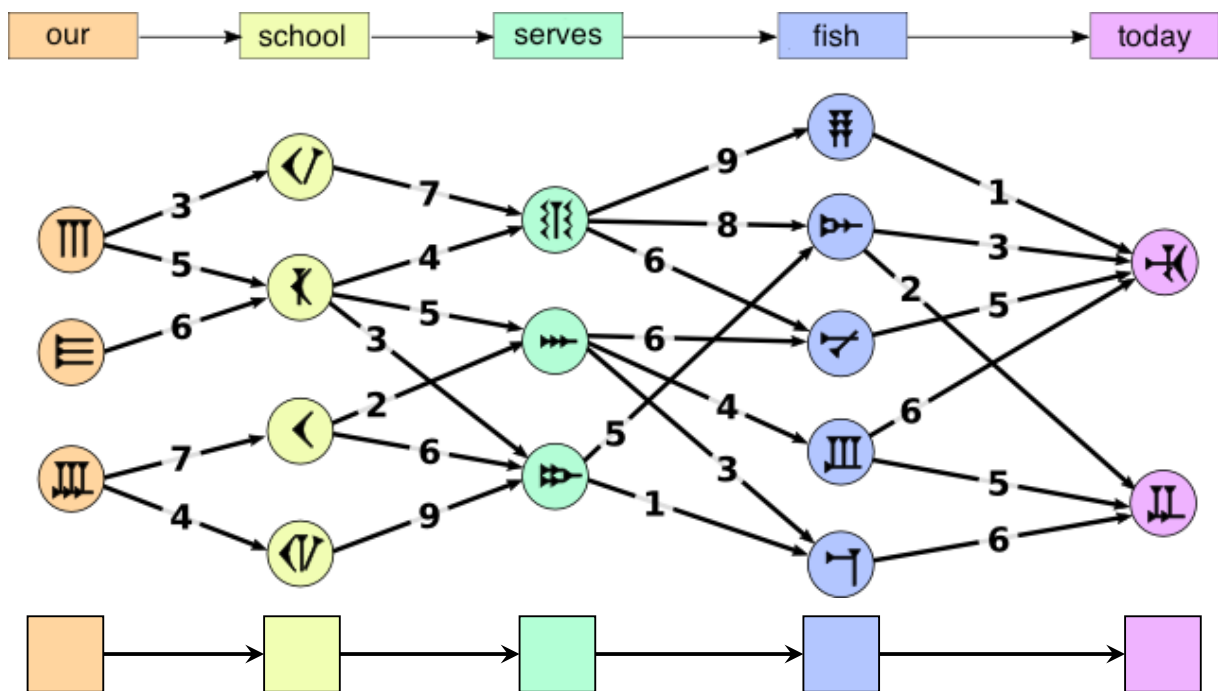
Determine the best translation.

Drag the correct symbol into the empty space underneath each word.

Save Answer

Erase

Answer:

The best possible score is 22.

Counting from top, choose the second, second, second, third and finally first symbol.
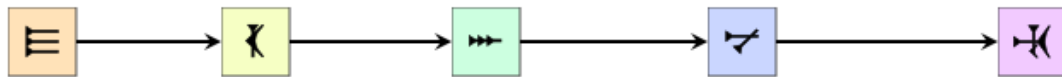
Explanation:

How can we find this quickly among all the valid translations? We should proceed systematically; for example word by word, from left to right. Let's say I am at the middle green point. I would like to know the best score I can get on the way to that green point. If I proceeded systematically, I have all the partial top scores to the left. So I can easily see, whether I should come from the second or the third yellow point. There is no other option! I can continue with the next green point and then go to the pale blues and proceed in the same manner. This way we can find the best score very fast. We use only 22 additions and some comparisons, instead of 36*3=108 additions, made by those who checked every possible way.

For extra fun, can you confirm that there are indeed 36 valid translations?

It's Computational Thinking:

Concepts - Abstraction (AB), Evaluation (EV), Generalisation (GE)

The smart idea to solve this quickly is called dynamic programming. It is based on a general idea of systematically building the solution from small chunks to bigger and bigger pieces. If you remember (or write down) the partial results, this can be done very quickly.

Also, this gives you a glimpse of contemporary machine translation such as used by *Google translate*. You may be surprised, but it does not depend on deep understanding of grammar. Rather, it works with enormous databases of texts in different languages, and simply put, looks for good matches. You might wonder if you can use this approach as a human to learn a new language. Unfortunately, a sufficient amount of text doesn't fit into a human brain, so you will still need to study proper grammar!

Website:

https://translate.google.com/about

Kits:
Castors:
Juniors:

Intermediates:
Seniors: C
Elite: C

Right rectangles

A robot has been programmed to draw rectangles. It can execute the following instructions:

Orange	draw an orange line of length 1
Black	draw a black line of length 1
Turn	turn 90° clockwise

Besides those simple instructions the robot can also execute complex instructions by combining instructions.

If A and B are instructions (either simple or complex) the robot can do:

A, B	first execute A and then execute B
n×(B)	execute B n-times

The robot must draw this pattern:
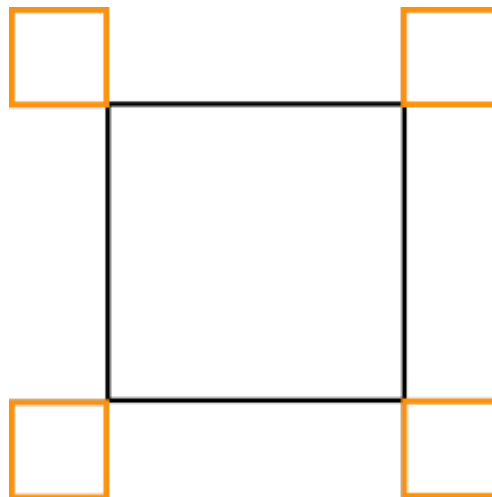
Which set of instructions does NOT result in the requested drawing?

4×(2×(Orange, Turn), Orange, 3×(Black), Orange, Turn)

4×(2×(Orange, Turn), 3×(Black), 2×(Orange, Turn))

4×(3×Black, 3×(Orange, Turn), Orange)

4×(Black, 3×(Orange, Turn), Orange, 2×(Black))

Answer:

4×(2×(Orange, Turn), 3×(Black), 2×(Orange, Turn))

Explanation:

Apart from the answer, all the other sets of instructions create the desired drawing but from a different starting point.

It's Computational Thinking:

Concepts - Algorithmic Thinking (AL), Evaluation (EV)

The program of the robot is a so-called algorithm, in other words a sequence of commands. It describes how a problem (here the drawing of the figure) is solved by decomposing the problem into many small individual steps.

These individual steps are repeatedly executed when needed (here, for example, 3 x Black to draw the long black line).

If the right commands are in the correct order, we have a program that solves the problem.

Kits: Intermediates:
Castors: Seniors:
Juniors: Elite: C

Height game

Young beavers Amy, Beavy, Cuttree, Diggy and Eary, want to play a game with you.

They all stand in a line. Then they each count how many beavers are taller than they are both infront of them and behind. They give you the results on a slip of paper:

Name	No. of taller beavers	
	infront	behind
Amy	1	2
Beavy	3	1
Cuttree	1	0
Diggy	0	0
Eary	2	0

In what order are the beavers standing?
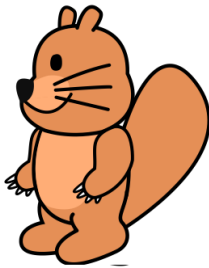
Diggy, Cuttree, Amy, Beavy, Eary

Amy, Cuttree, Diggy, Eary, Beavy

Diggy, Amy, Cuttree, Beavy, Eary

Diggy, Amy, Eary, Beavy, Cuttree
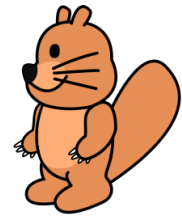
Answer:

Diggy,   Amy,   Cuttree,   Beavy,   Eary

Explanation:

First establish the height order. e.g. Diggy is tallest as there are no beavers taller than her and Cuttree is next, down to Beavy who is the shortest because there are a total of 4 beavers taller than her. It can be helpful to assign the beavers height integers like this:

Diggy(5)	Cuttree(4)	Eary(3)	Amy(2)	Beavy(1)

Now it is much easier to assign the positions: Diggy must be at the front, as all the others have beavers in front of them. Beavy must be in the fourth position because she has three beavers in front of her and one behind:

Diggy(5)			Beavy(1)	

Because Amy has two taller beavers behind her (who must be Cuttree and Eary) and Beavy is smaller than her, Amy must be in the second position:

Diggy(5)	Amy(2)		Beavy(1)	

Finally, because Eary has no taller beavers behind her, she must be behind Cuttree and thus in the last position. So we also know where Cuttree is:

Diggy(5)	Amy(2)	Cuttree(4)	Beavy(1)	Eary(3)

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Evaluation (EV)

Sorting is an essential concept in computer science. The solution to many problems may require sorting as a necessary first step. It allows us to order the unordered data and simplify solving the algorithm.

Logic and computer science are deeply connected. When solving a logical problem, as well as writing a computer program, it really helps to approach the problem step by step and establish intermediate results that can then be used to solve the full problem.

Meeting point

Kits: Intermediates:
Castors: Seniors:
Juniors: Elite: C
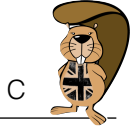
Three friends Anne, Bernie and Clara live in a city with an underground train system.

The map of the system below shows the stations and connections between the stations.

The map also indicates how many minutes each connection takes.
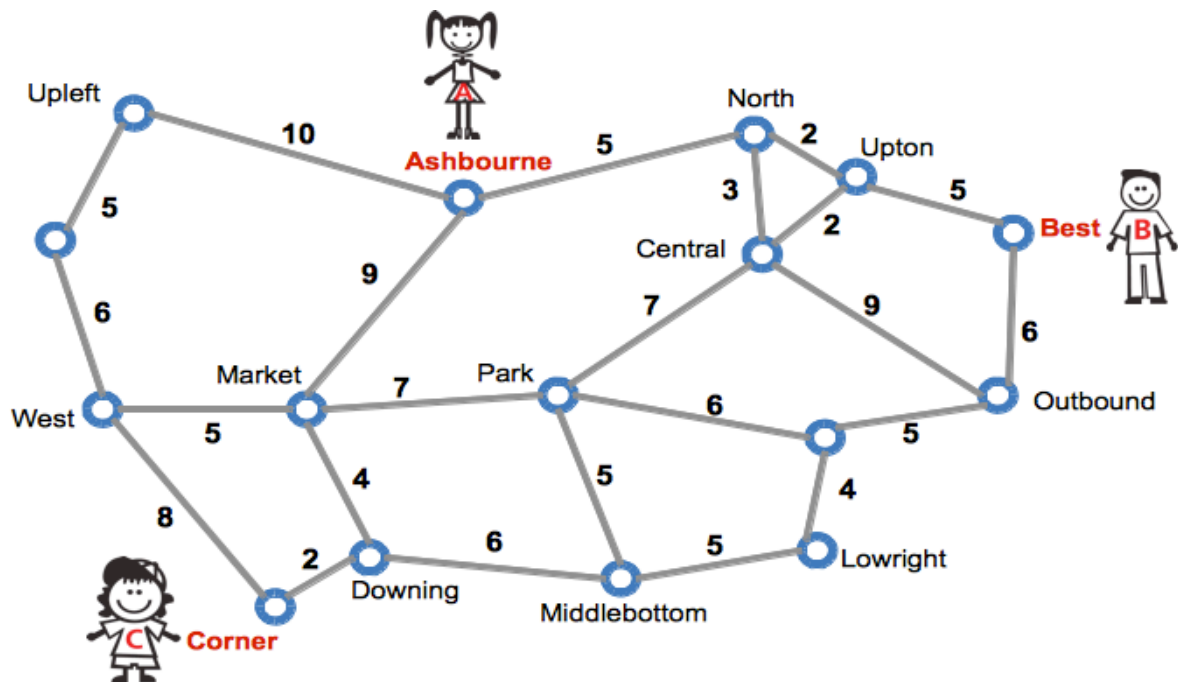
Anne lives next to Ashbourne station, Bernie's nearest station is Best, and Clara's is Corner. They wish to select a station for a meeting. None of the friends should take more than 15 minutes of travel to reach the meeting point.

Which stations qualify as possible meeting points?

Click on all of the stations that would qualify as suitable meeting points.

Answer:

Ashbourne and Park are good meeting points

Explanation:

In order to solve this problem, we have to know to which stations we can travel to from each of Ashborn, Best and Corner, in less than 15 minutes. To do this, we add up the times that constitute the shortest route to any other station.

So from Ashbourne we find we can get to Ashbourne(0), (North,5), Upton(7), Best(12), Central(8), Park(15),(Market,9), Downing(13), West(14) and (Upleft,10).

We then do the same for Best and Corner, and keep the stations which are common for the three.

Alternatively we can use Dijkstra's algorithm:

Let us take Ashbourne as the starting station. We make a temporary list of stations, and their time of travel, which at the beginning is empty. First, we add (Ashbourne,0) to this list: we can travel to Ashbourne in 0 minutes. Then we take the station with the lowest minutes from the temporary list: (Ashbourne,0). Now we mark that Ashbourne takes 0 minutes. Then we add to the temporary list all the neighbours of Ashbourne, with their total times: (North,5), (Upleft,10) and (Market,9).

We then take the nearest station from the temporary list: (North,5) and declare that North is 5 minutes from Ashbourne. Then we add the neighbours of North with the sum of the times: (Upton,7) and (Central,8). We do not add Ashbourne because we already know we can get to it faster. The list is now (Upleft,10), (Market,9), (Upton,7), (Central,8). We repeat the process until all stations in the temporary list take more than 15 minutes to get to.

This gives us the minimal time for every station. After we have done the same for Best and Corner, we can keep the stations which are common for the three.

It's Computational Thinking:

Concepts - Abstraction (AB), Algorithmic Thinking (AL), Decomposition (DE), Evaluation (EV), Generalisation (GE)

The mathematical concept of a relationship is heavily employed in the area of Computational Thinking. Large databases rely on so-called relational models. One way of representing relationships between elements of the same set is in a "graph": the elements are called "nodes", and "edges" are pairs of related nodes. In specialised graphs, edges may have a direction (node a is related to node b, but not vice versa) or weights. A traffic network like the one of this task can be modelled - and visualised - as a graph with weighted edges, with the weights representing the time of traveling distances. The good thing is that Computer Scientists have developed many efficient algorithms for such graphs, e.g. several ones to find shortest paths. Obviously, shortest path algorithms are useful for route planning - and many other applications.
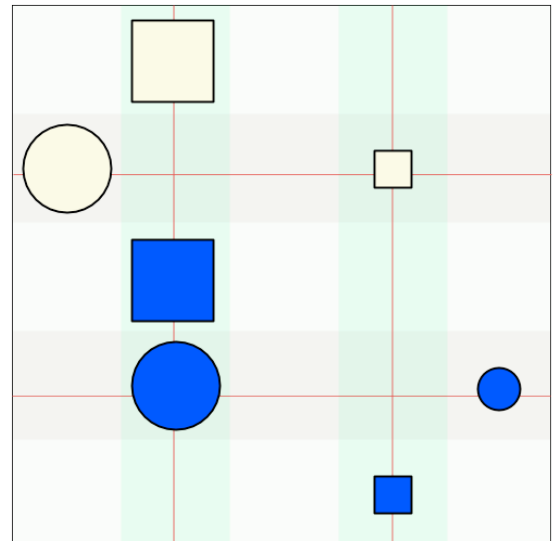
🇷🇺 True or false
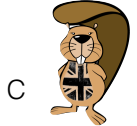
Alice and Tom are playing a game of "True or False" on their colourful, magnetic whiteboard in their classroom.

Alice has stuck seven different magnetic shapes on the board.

She then makes four statements about the shape, colour, size and position of the shapes.
Only one statement is allowed to be true.
Tom must figure out which one it is.

Which of the following statements is true?

A. There are two shapes X and Y, so that X is dark blue and Y is pale yellow and X is higher than Y.
B. For all pairs of shapes X and Y, if X is a square and Y is a circle, then X is higher than Y.
C. For all pairs of shapes X and Y, if X is small and Y is big, then X is to the right of Y.
D. For all pairs of shapes X and Y, if X if light yellow and Y is dark blue, then X is below Y.

Answer:

C

Explanation:

The correct answer is C since every small shape is to the right of every large shape.
There is no dark blue shape above a light yellow shape, so A is false.
Not all squares are above every circle, so B is false.
Not all light yellow shapes are below every dark blue shape, so D is false.

It's Computational Thinking:

Concepts - Algorithmic Thinking (AL), Evaluation (EV)

The game is about determining whether logical statements are true or false. Each statement can be expressed in predicate logic. The properties of a shape X can be represented by the predicates square(X), circle(X), large(X), small(X), blue(X), and yellow(X). The relations between a pair of shapes X and Y can be represented by the predicates above(X,Y), below(X,Y) and right(X,Y). Using these predicates, the statements can be expressed formally as:

A) exist X, Y: blue(X) and yellow(Y) and above(X, Y)

B) forall X, Y: (square(X) and circle(Y)) implies above(X, Y)

Answer:

4×(2×(Orange, Turn), 3×(Black), 2×(Orange, Turn))

Explanation:

The correct answer is C since every small shape is to the right of every large shape.

There is no dark blue shape above a light yellow shape, so A is false.

Not all squares are above every circle, so B is false.

Not all light yellow shapes are below every dark blue shape, so D is false.

It's Computational Thinking:

Concepts - Algorithmic Thinking (AL), Evaluation (EV)

The game is about determining whether logical statements are true or false. Each statement can be expressed in predicate logic. The properties of a shape X can be represented by the predicates square(X), circle(X), large(X), small(X), blue(X), and yellow(X). The relations between a pair of shapes X and Y can be represented by the predicates above(X,Y), below(X,Y) and right(X,Y). Using these predicates, the statements can be expressed formally as:

A) exist X, Y: blue(X) and yellow(Y) and above(X, Y)

B) forall X, Y: (square(X) and circle(Y)) implies above(X, Y)

C) forall X, Y: (small(X) and large(Y)) implies right(X,Y)

D) forall X, Y: (yellow(X) and blue(Y)) implies below(X,Y)

Predicate logic is important in computer science for specifying and proving properties of computer systems. It is also possible to automate logical reasoning so that computers can draw logical conclusions. There are even programming languages based on predicate logic such as Prolog which is an example of a logic programming language.
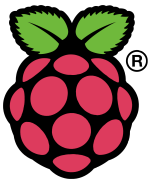
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www.computingatschool.org.uk

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