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# Bebras Australia Computational Thinking Challenge Tasks and Solutions 2016

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## Acknowledgements

We would like to thank the international Bebras community for allowing us to use the tasks that they have developed in this new round. Bebras is a collective effort of many countries and we are privileged to be part of the Bebras community. This year, Bebras Australia runs with the same set of questions as the UK and we would like to thank Bebras UK for their generous support in terms of the tasks in the system, but also in relation to the creation of this solutions book.

Computer Science is a very international discipline, and Bebras embodies this principle outstandingly.

Special thanks go to Eljakim Schrijvers from The Netherlands who is a master of the Bebras System and a key go-to person for Bebras Tasks. We would like to particularly thank the following individuals for their help and support: Daphne Blokhuis, Peter Millican, Chris Roffey and Sue Sentan.

We would like to thank the Australian Government as represented by the Department of Industry, Innovation & Science for providing funding to the Digital Careers Initiative which is running Bebras Australia.

We would also like to thank the Australian Curriculum, Assessment and Reporting Authority (ACARA) for providing advice regarding Computational Thinking in the Digital Technologies Curriculum.

Special thanks to the Australian teachers who promote and use Bebras. We have heard many great stories about your creativity in delivering engaging Digital Technologies Education in the classroom.

## Introduction

### About Bebras Australia

The Bebras Australia Computational Thinking Challenge was established in 2014 to enable Australian primary and secondary school students from years 3-12 to experience Digital Technologies without programming. The format is designed to engage students in a light and problem-oriented way.

For Australia, we have developed the two characters Bruce and Beatrix who, with their fellow beavers from



overseas, accompany the students on their journey. Beavers are hardworking animals that sink their teeth into problems and work tirelessly until they have accomplished their task. This is how we imagine our young computer scientists.



#### Everyone can do it

The challenges consist of a set of short questions called Bebras tasks that are delivered via the internet. The tasks can be answered without prior knowledge about Computational Thinking, but are clearly related to Computational Thinking concepts.

It is hoped it will raise general interest in Computer Science and young people to understand that Computational Thinking has wide application in solving all sorts of problems that might be met in life. The philosophy emphasises participation whilst celebrating achievement.

#### Work alone or in teams

Students can work alone or in teams of up to four students. To solve the tasks, students are required to think about information, how information is organised, how data will be processed, and make decisions that can both demonstrate an aspect of computational thinking and test the talent of the participant.

In each age group, there are 15 tasks to be solved. These are presented under three levels of difficulty – Easy, (A) Medium (B), Hard (C) – each consisting of five questions. The questions get progressively more difficult as students progress through the levels of schooling.

Bebras supports the new Australian Curriculum: Digital Technologies.

# Bebras: International Contest on Informatics and Computer Fluency

Bebras is an international initiative whose goal is to promote computational thinking for teachers and students (ages 8-18; years 3-12).

The idea of Bebras was born in Lithuania, by Prof. Valentina Dagiene from University of Vilnius. Bebras is the Lithuanian word for “beaver”. The idea emerged during the travel around Finland in 2003 and discussions about how to attract students



to learn informatics. The activity of beavers in strands was so noticeable, that it suggested the symbol of the contest... Beavers look like persistent workers who endeavour for perfection in their field of activities and beaver away to reach the target. Their everyday job seems to be a trial: the one who pulls down more trees will stem more streams... Therefore, our competition was named after the hard-working, intelligent, and lively beaver.

The first Bebras contest was organised in Lithuania in 2004. By 2015, the Bebras contest had spread across the world with more than 1,000,000 participating students; 20,000 of which came from Australia.

The international Bebras Community jointly develops tasks for Bebras Week which is held annually. Australia, New Zealand, the UK, Ireland, South Africa, the United States, Japan, Canada, The Netherlands, Austria, Switzerland and Germany use a common online system to deliver the Bebras tasks to students.

Further information about Bebras International and its member countries is available at [www.bebbras.org](http://www.bebbras.org).

# Participating Countries

Each task in this booklet has a flag indicating the country of origin. However, many people were involved in the further editing, translating and providing additional material.

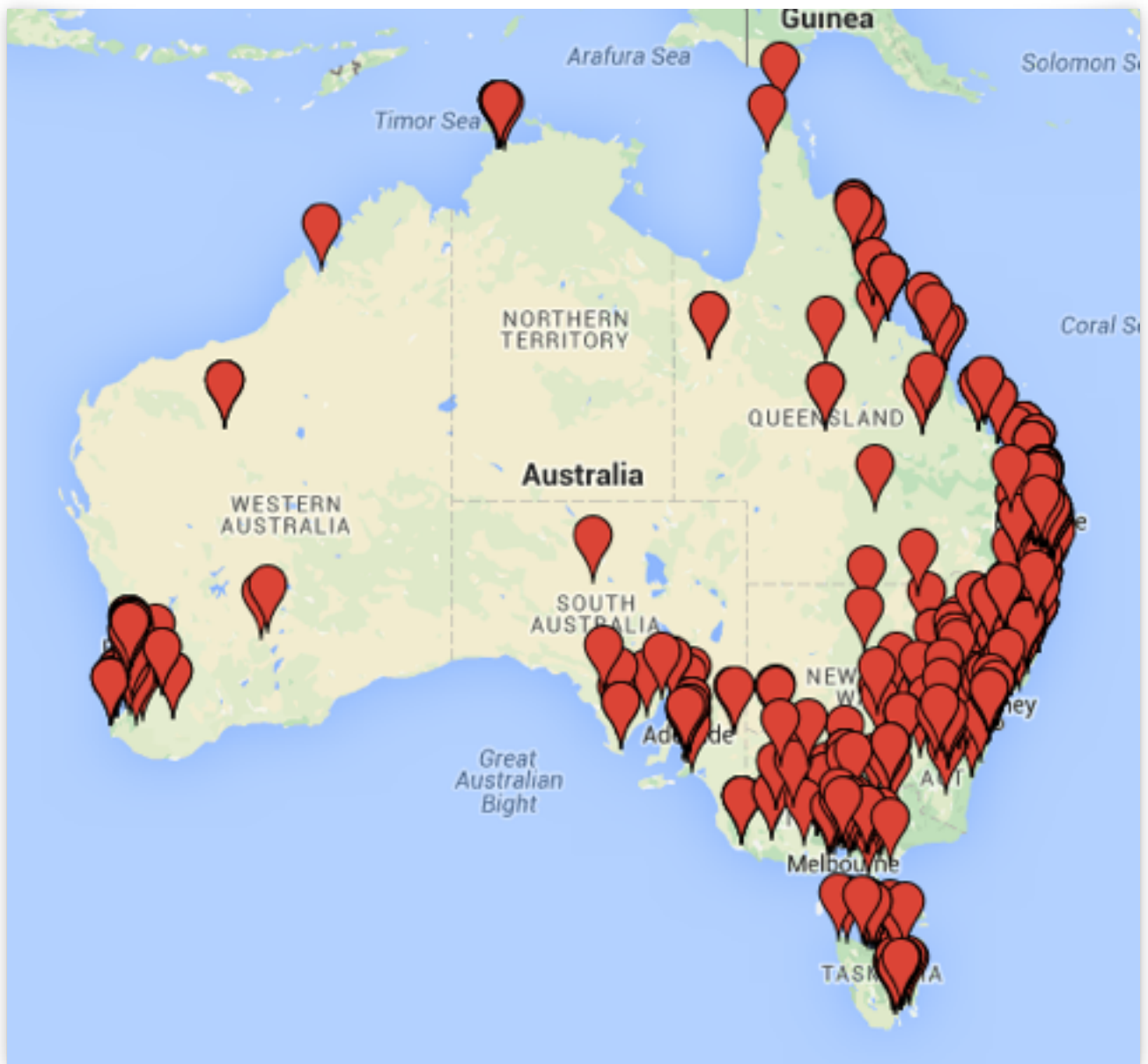
After each question there is an answer, an explanation of how the answer could be obtained plus a section on how the tasks are related to Computational Thinking. We have also mapped the tasks to the Australian Digital Technologies Curriculum. It is our sincere hope that the Computational Thinking information provided will enhance the usefulness of this booklet for Digital Technologies teachers and their students whether in the Primary or Secondary phase. It is for this reason that this booklet is being made freely available as a PDF that can be further distributed freely. We are indebted to the generosity of spirit and community of Computer Scientists around the world!





# Welcome Australian Students

Across Australia, in all States and Territories, teachers from schools and home schools alike have registered as Bebras coordinators. We have plotted their origins on this map as a celebration of the diversity of the many places our coordinators and their students come from.



# Contents

On the following pages you will find the tasks of this year's Bebras Australia Computational Thinking Challenge. Most tasks are used in multiple year levels. Below we list the tasks, their difficulty ratings, and the pages on which you can find them.

Bebras Task	Year Level					Page
	3+4	5+6	7+8	9+10	11+12	
Bracelet	A	A	A			8
Dream Dress	A	A	A			9
Crane Operating	A	A				10
Mushrooms	A	A				11
Birthday Balloons	A					12
Setting the Table	B	A				13
Animation	B	B	A			14
Biber-Hotel	B	B	A			15
Geocaching	B	B	A			16
Walnut Animals	B	B				18
Trains	C	B				20
Throw the Dice	C	C	B	B		21
Drawing Patterns	C	C	B			22
Fair share	C	C	C	B		23
Beaver Gates	C	C				24
Cross Country		C	B			26
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You Won't Find It			B	A	A	29
Theatre			C	B		30
Beaver Lunch			C	C		32
Animal Competition			C			34
Chakhokhbili			C			35
E-mail Scam				A	A	37
Super Power Family				A		38
Irrigation System				A		39
Word Chains				B	A	40
Popularity				B	B	41
Stack Computer				C	B	43
Beaver the Alchemist				C	B	45
Fireworks				C		46
Mobiles				C		47
Beaver Tutorials					A	48
Super Power Family (hard)					B	49
Kangaroo					B	50
Bowl Factory					C	52
Reaching the Target					C	54
Fireworks (hard)					C	55
Mobiles (hard)					C	56
Spies					C	57



# Bracelet

Age Group: Difficulty

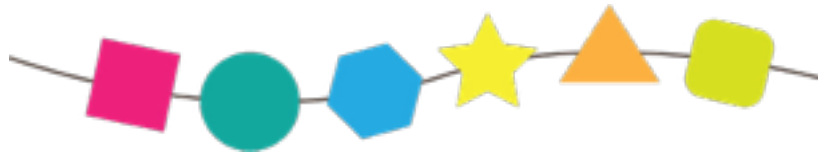
3+4: A

5+6: A

7+8: A



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



### Question:

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



A



B



C



D

### Answer:

The correct answer is B

### Explanation:

Bracelet B follows the beads in the same order as the broken bracelets.

### It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models*

In computational thinking it is important to be able to recognise patterns which may be useful to us. Recognising patterns helps us find similarities in things that may look different at first, but have something in common.

This task also deals with verifying a proposed solution: the possible answers need to be checked against the original bracelet to see if they meet the required order of the shapes. The same process of verifying a solution is important in computing in order to determine if the output of a program is correct.





Kate wants to buy her dream dress.

It must have:

- short sleeves,
- more than 3 buttons,
- stars on its sleeves.



Four shops sell only the dresses shown.

**Question:**

Which of these shops sells Kate's dream dress?

BeaverYorker, BeaverNova, B&B or TomTeaver

**Answer:**

The correct answer is B&B

**Explanation:**

To solve this task, we must simultaneously satisfy three requirements. This can be done by ruling out dresses that do not meet any one of the requirements. After doing this, one can see that the dress on the bottom left sold by B&B is Kate's dream dress.

**It's Computational Thinking:**

*Breaking down problems into parts, Organising data logically, Interpreting patterns and models*

The task involves statements (conditions/requirements) that must be evaluated (determined to be true or false) for a set of objects (coats). Conditions and their evaluation is an important part of programming and algorithmic thinking.

Conditions can be simple statements. However, more complex statements can be formed using logical operators such as AND, OR, NOT, ... This task uses the AND operator.



# Crane Operating

Age Group: Difficulty  
3+4: A  
5+6: A



The crane in the port of Lodgedam has six different input commands:

- left
- right
- up
- down
- grab
- let go



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

## Question:

Using the command buttons, swap the position of the two crates.

## Answer:

Down, Grab, Up, Right, Down, Let go, Up, Right, Down, Grab, Up, Left, Left, Down, Let go, Up, Right, Down, Grab, Up, Right, Down, Let go

## Explanation:

When operating machines and computers, you must put the commands in the correct order. This is an interactive problem so most students will get this correct.

## It's Computational Thinking:

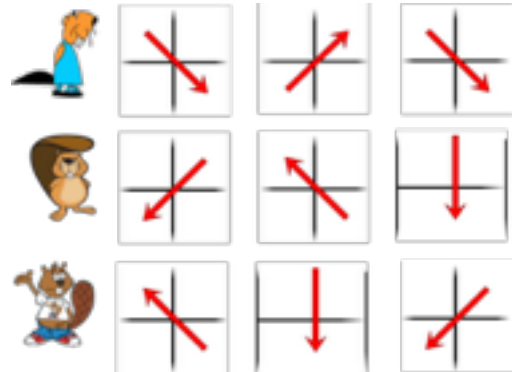
*Designing and implementing algorithms*

In this problem a sequence of instructions is searched for. A set of instructions is called an algorithm. In this problem two objects can only be changed if one of the objects is placed on an empty place.

Most computers still work with sequentially run programs, so each exchange operation in the memory of the computer also needs an extra space.



Three beavers are standing in a forest.  
 Each wants to go where there are mushrooms.  
 Arrows in the picture to the right show the directions the beavers will walk.



**Question:**

Where do the beavers end up?

**Answer and Explanation:**



**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Designing and using algorithms*

Simple sets of instructions called algorithms can help us solve problems. It is sometimes easier to do this with pictures and arrows than with words.



Mother Beaver bought ten balloons of three colours with the numbers as shown:

- 0 Green
- 1 Yellow
- 2 Red
- 3 Green
- 4 Yellow
- 5 Red
- ... etc.



### Question:

If Mother Beaver was born in the year 1983, can you pick up the balloons in the correct order to show Mother Beavers' year of birth?

Yellow, Red, Green, Red

Yellow, Green, Green, Green

Yellow, Red, Red, Green

Yellow, Green, Red, Green

### Answer:

Yellow, Green, Red, Green

### Explanation:



### It's Computational Thinking:

*Organising data logically, breaking down problems into parts, Interpreting patterns and models*

It's computational thinking, because the solution of the problem uses matching, ordering and assignment of numbers with colours (information comprehension). Another important idea is lossy data compression (for coding of 10 digits we have only 3 colours.)

# Setting the Table

Age Group: Difficulty  
3+4: B  
5+6: A



Beaver Bob has set the breakfast-table as shown in the picture.



## Question:

In which order has he placed the objects on the table?

- A. table cloth, napkin, cup and saucer, knife, plate
- B. table cloth, napkin, cup and saucer, plate, knife
- C. napkin, knife, table cloth, cup and saucer, plate
- D. table cloth, cup and saucer, napkin, plate, knife

## Answer:

Choice D

## Explanation:

The table cloth was placed first because all the other things are on it. The next was the cup because the napkin is on the cup. The plate is on the napkin and the knife is on the plate.

## It's Computational Thinking:

*Breaking down problems into parts, Organising data logically, Designing and implementing algorithms.*

Sequences are important in computational thinking.

When you give instructions to a computer, those will be implemented in the order in which they are given.

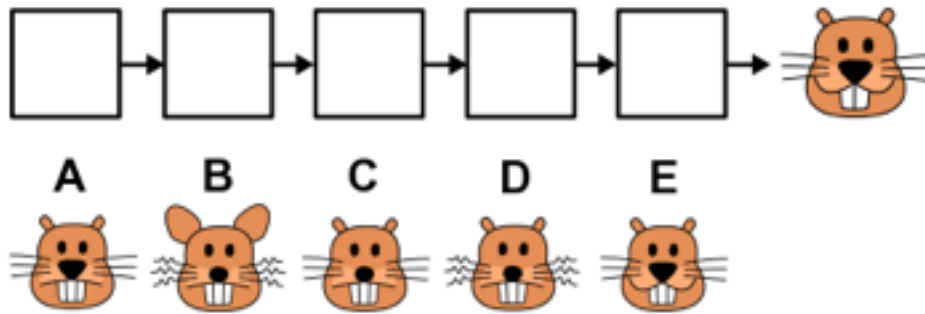
Layers (sequence of pictures) are important when making graphics programs. In a picture you can separate different elements and change their sequence.



Taro is planning an animation of a face that is made from a sequence of pictures.

To make the animation run smoothly, only one feature of the face should change from one picture to the next.

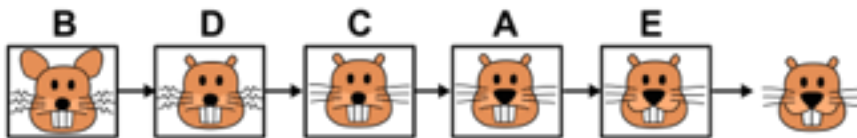
Unfortunately, the pictures got mixed up. Now Taro must find the correct order again. Luckily, he knows which picture is last.



### Question:

Put the pictures in the correct order by dragging them onto the squares.

### Answer:



### Explanation:

The ears change from large to small. The whiskers change from curly to straight. The nose changes from small to large. The mouth changes from plain to smile. The number of teeth changes from 3 to 2. It is best to work backwards to solve this!

### It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

In order to find the differences between the pictures, you have to find about about the essential attributes of the faces first. The list of attributes and their possible values is:

- |                       |                           |                    |
|-----------------------|---------------------------|--------------------|
| ears: small, large    | mouth: plain, smile       | nose: small, large |
| number of teeth: 2, 3 | whiskers: curly, straight |                    |

Face A can now be described as:

(ears: small; mouth: plain; nose: large; number of teeth: 3; whiskers: straight)

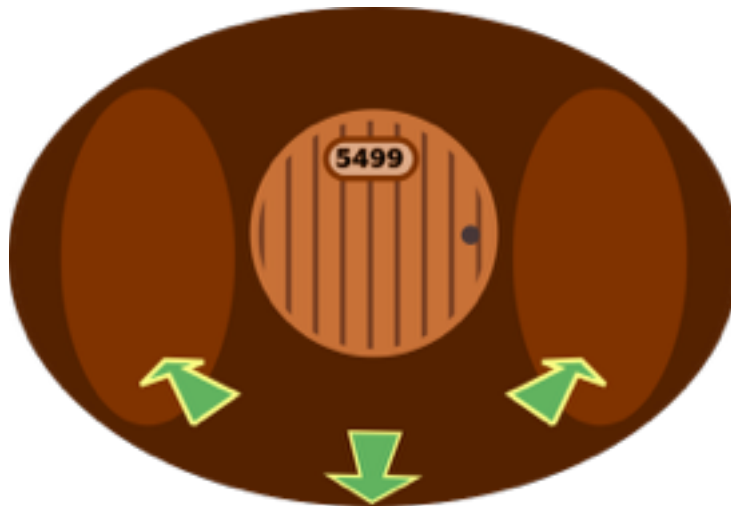
In computing, it is very usual to model things from the real world as “objects” that have attributes and values.





Over the years, the beavers constructed a huge beaver den with many, many rooms. The rooms are numbered and arranged in a particular tunnel structure.

Click on the arrows in the picture to move through the den.



### Question:

Find the room with **number 1337**. Click on 'Save' once you've found it.

### Answer and explanation:

The numbers are arranged in such a way that choosing a left exit brings you to a room with a lower number, and choosing the right exit brings you to a room with a higher number. Once you realise this, it is very easy to click correctly and you will find the room you are looking for.

Click on the floor to go back one step.

### It's Computational Thinking:

*Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

The structure of the beaver den is a so called a “binary tree”, meaning that from every room (a so called “node”) there are (possibly) two branches leaving to further rooms. The room-number (or any other ordered data) serves to navigate and find a room again. Data on a computer can also be organised in such way (like for instance names and phone numbers).

Despite having several millions of entries, an entry (or its absence) can be found in less than 25 comparisons. In fact, with at most  $n$  comparisons (also called the “depth” of the tree) it is possible to distinguish between  $2^n - 1$  entries. For  $n=10$  we have 1023 possible entries, for  $n=20$  we have a little over 1 million entries and for  $n=30$  over one billion.

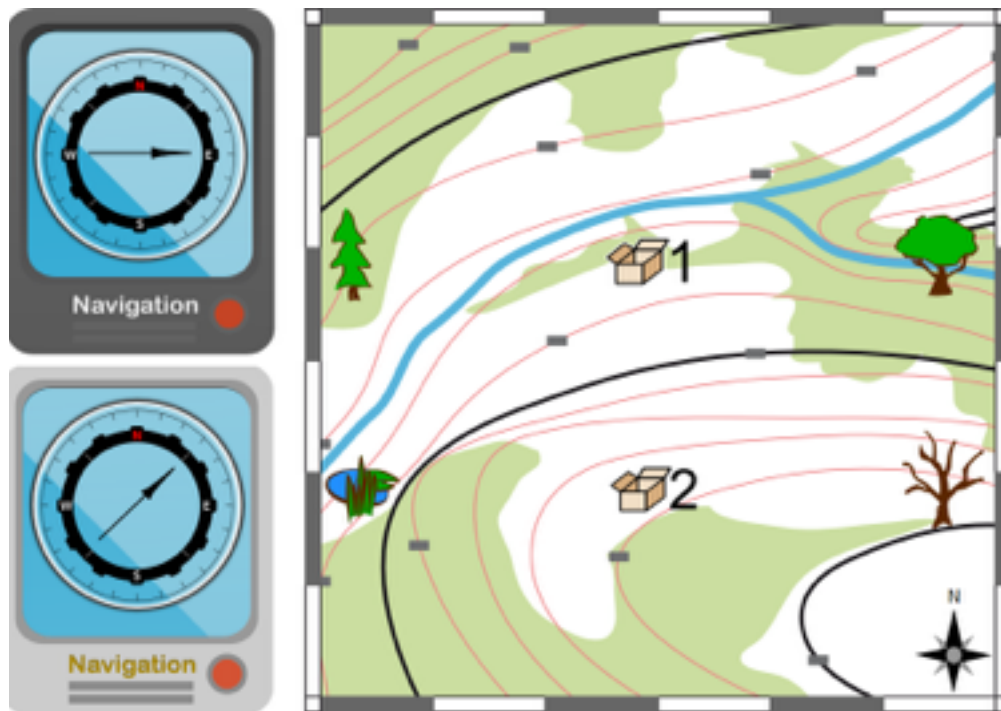


Two friends, Anna and Bob, are searching for treasure.

They have a smartphone app that shows them the direction to the treasure they are looking for.

The two boxes on the map show where the treasure is is.

Anna is searching for box 1. Bob is looking for box 2.



Anna and Bob are standing in the same place. The picture shows the map and a screenshot of the smartphones.

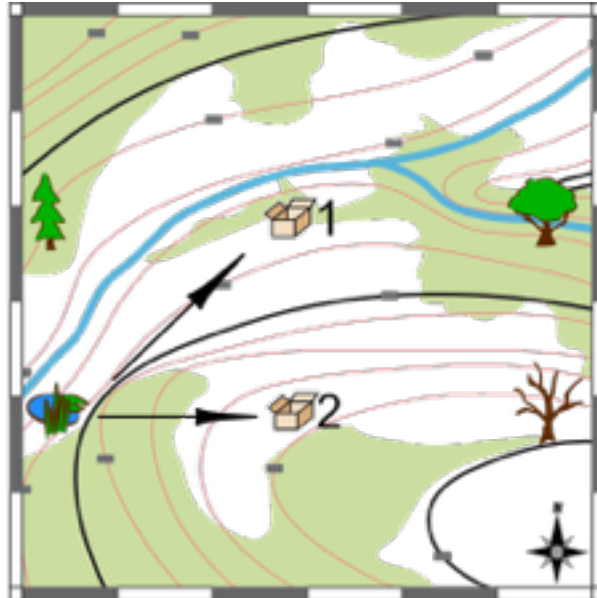
**Question:**

Where are Anna and Bob standing?



# Geocaching

## Answer and Explanation:



## It's Computational Thinking:

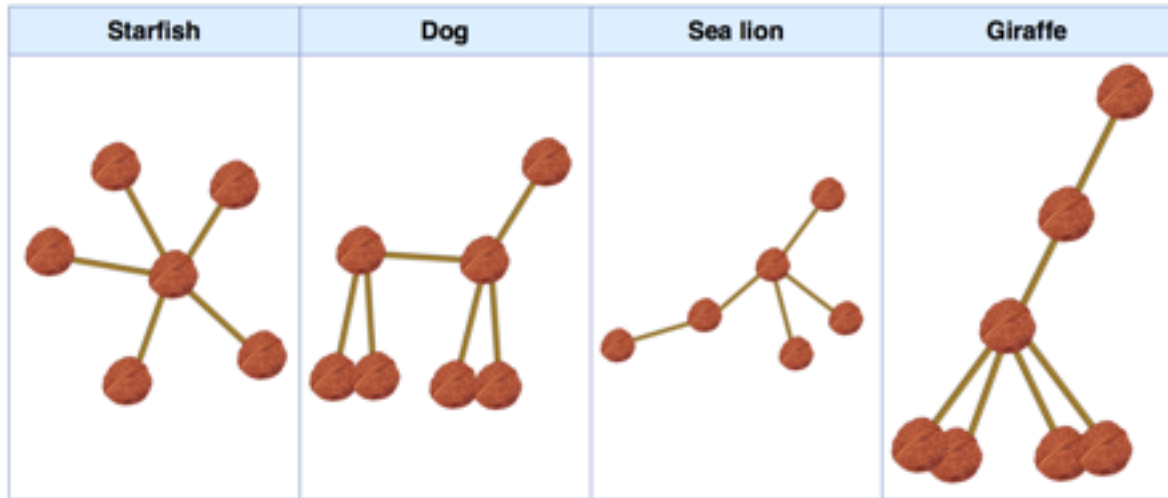
*Interpreting patterns and models, Breaking down problems into parts, Organising data logically*

Geocaching is a nice game which uses the global navigation system of the Earth. There are a lot of applications of GPS: car navigation, rescue of lost people, traffic control, localisation of stolen cars and bikes.

In this task, you have to discover the role of the arrow in both devices. So you have to understand the description of a situation and to project it into a graph (or map).



Gerald was playing in the woods. He used nuts and sticks to create four nice animals.

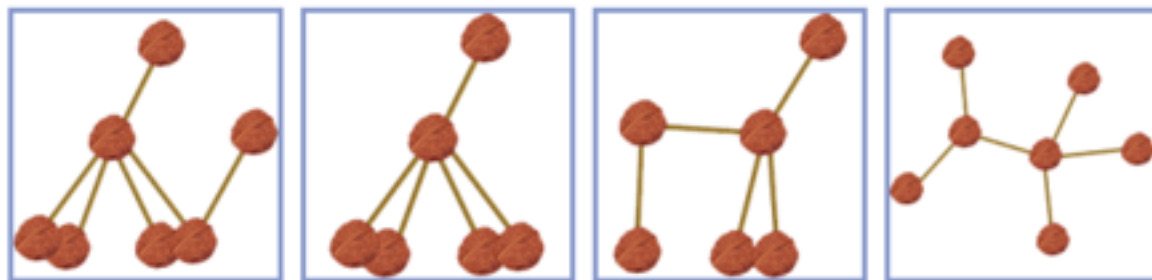


His sister managed to bend the animals around without removing any of the sticks.

Gerald was very upset because he really loved the figure of a dog.

**Question:**

Which of the following figures can be bent back to make the figure of the dog again?



# Walnut Animals

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## Answer:



## Explanation:

Each animal can be described by the connections between its parts. The specific positions of parts and angles of connections may change while being played with, but that does not change the animal itself. So we need to determine pairs of pictures with the same structure on them. Let's start with the starfish. It has a regular structure and is therefore easiest to spot: one central part and five arms. There is only one possibility among the transformed animals

## It's Computational Thinking:

*Interpreting patterns and models, Designing and implementing algorithms.*

With walnut animals, we abstract features like fur and size. We represent the animal only by the structure of its body, the rest is unimportant. This structure is preserved even when the animals are transformed. A computer scientist must recognise what is important, what can be left out, and how structures are similar.

If the animals in our task were just a bit bigger and more complicated, it would be extremely difficult to identify them. That is why computer scientists try to invent efficient algorithms to solve such problems.

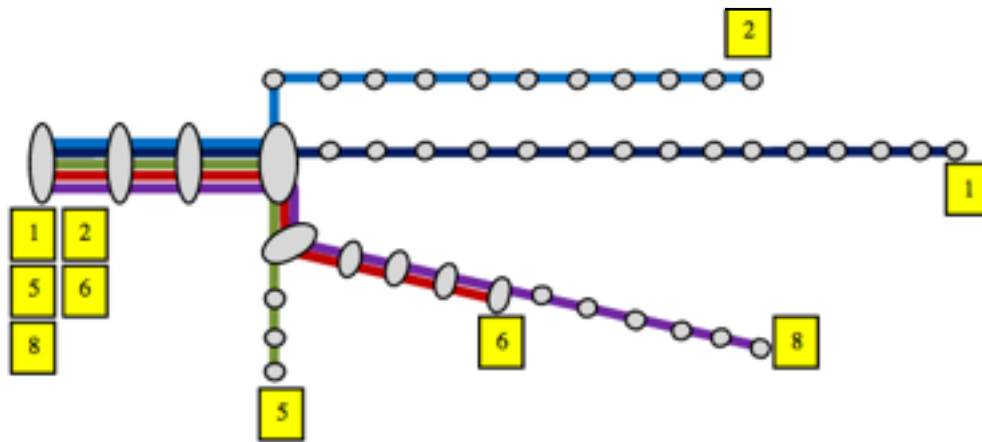


The train lines in Beaver City all have their own number.

Unfortunately the numbers are only shown on this map.

When you are on a train you cannot see the line number anywhere!

You get onto a train at the main station where all the lines begin.



After three stations your train makes a turn.

At the next station it makes another turn.

Four stations later you have arrived at your destination.

**Question:**

Which train line were you on?

1, 2, 5, 6 or 8

**Answer:**

Line 6

**Explanation:**

This problem is solved by following the instructions carefully and ruling out routes that do not allow the train to complete its journey. So after three stations a turn needs to be made, ruling out line 1 but the other lines still need to be checked.

**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

It is quite common when writing programs to find that your code produces unexpected results. Careful stepping through instructions is the first part of identifying where the problem is.



# Throw the Dice

Age Group: Difficulty

3+4: C

5+6: C

7+8: B

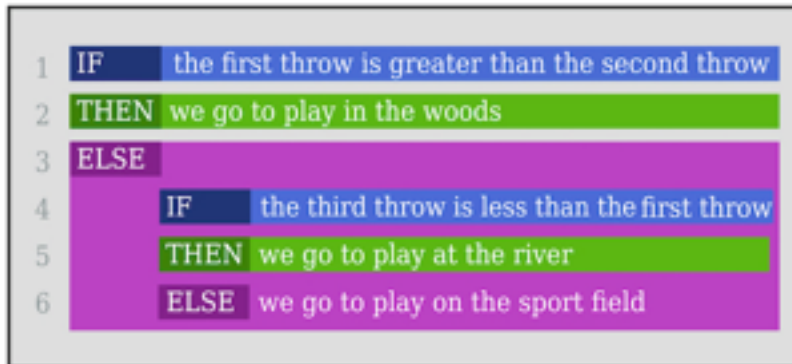
9+10: B



After school the young beavers often play together.

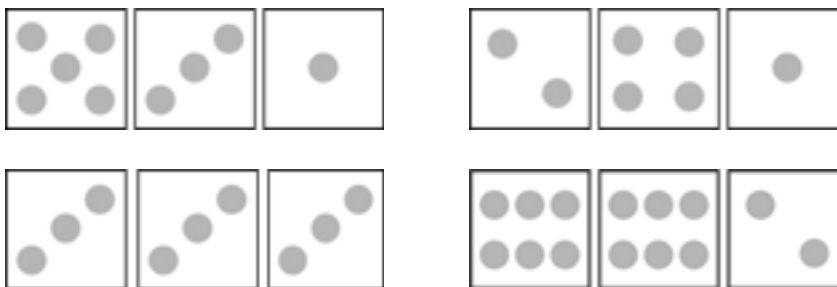
To avoid quarrels about where to play, they throw a normal six sided die.

The decision is found according to this rule:

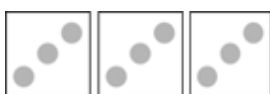


## Question:

Which sequence of throws will send the young beavers to the sports field?



## Answer:



## Explanation:

The first throw of 3 is not greater than the second throw of 3, so the ELSE-IF branch decides. The third throw of 3 is not greater than the first 3 thrown so the rule sends the young beavers to the sporting field.

## It's Computational Thinking:

*Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

"IF-THEN-ELSE" is a form of selection widely used in programming languages. It decides, depending on the current situation, about a program's next action. The "IF-THEN-ELSE" can suggest that being able to make a dual decision is the standard case in life. This tempts beginners programmers to use far too simple world models in their apps. Using nested "IF-THEN-ELSE" constructs or "CASE" (or in Python IF-ELIF-ELIF- ...) constructs enables more complex scenarios to be handled.



Your job is to create a program that draws the image shown below.

Clicking the buttons on the left, will put the instruction in the slot on the right.

The instruction clicked first will go at the top, the second below that, etc. The pattern of instructions you make will be repeated six times.

Test your program by clicking the button labeled "Run my program".

**When you are happy with the result remember to save your answer.**

Step right

Step left

Step up

Step down

Repeat 6 times

Target pattern:

Your pattern:

Run my program

### Answer:

Repeat six times

Step right

Step up

Step right

Step right

Step down

Step right

### It's Computational Thinking:

*Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

This problem asks us to write a program, including a sequence of instructions within a simple loop.



Hamid has a 4 litre beaker full of a hazardous chemical.


Kazim has an empty 3 litre beaker and another empty 1 litre beaker.

Hamid and Kazim want to share the chemical between them equally and need a machine to do this safely.

The machine can pour one beaker in to another. It stops pouring when a beaker is completely emptied or filled, whichever happens first.

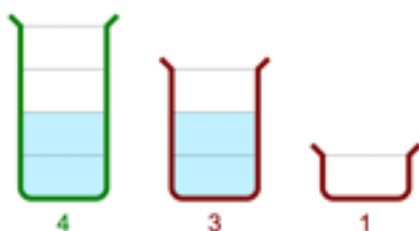
**Question:**

Find the sequence of pours that produces equal shares of the chemical for Hamid and Kazim. Your sequence must use the minimum number of pours possible.

Start	Choose the pours	Build the sequence										
	<table border="1"> <tr><td>4 → 3</td></tr> <tr><td>4 → 1</td></tr> <tr><td>3 → 4</td></tr> <tr><td>3 → 1</td></tr> <tr><td>1 → 4</td></tr> <tr><td>1 → 3</td></tr> </table>	4 → 3	4 → 1	3 → 4	3 → 1	1 → 4	1 → 3	<table border="1"> <tr><td> </td></tr> <tr><td> </td></tr> <tr><td> </td></tr> <tr><td> </td></tr> </table>				
4 → 3												
4 → 1												
3 → 4												
3 → 1												
1 → 4												
1 → 3												

**Answer:**

4 → 3
3 → 1
1 → 4



**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

This task involves a classical solution search. It is a relatively easy example of a classic puzzle. There are a number of computational thinking strategies that could be employed: For a simple puzzle like this a brute force strategy works (try everything systematically until the correct answer is achieved.) This is a common technique used by computers which takes advantage of their speed. With very complex problems though other techniques might be better employed such as backtracking, breadth-first search, etc.

# Beaver Gates

Age Group: Difficulty  
3+4: C  
5+6: C

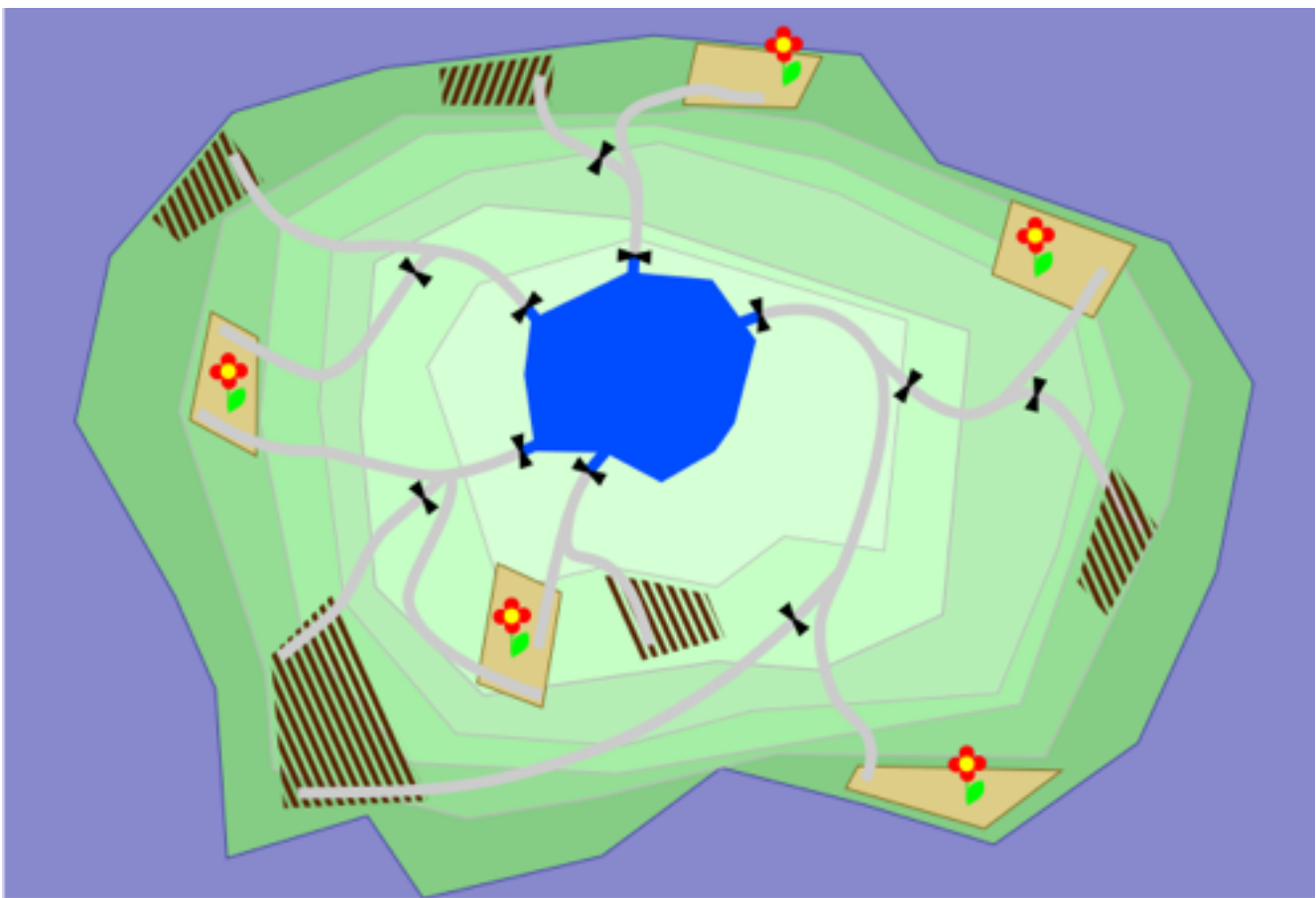



The Birchtree family needs to water their fields. Only fields with flowers need to be watered. The other fields must remain dry.


Click on a black gate to close or open it.

If it is open, water will flow from the lake in the middle to the fields below.

Help the Birchtree family produce a plan by clicking on the gates to open or close them.

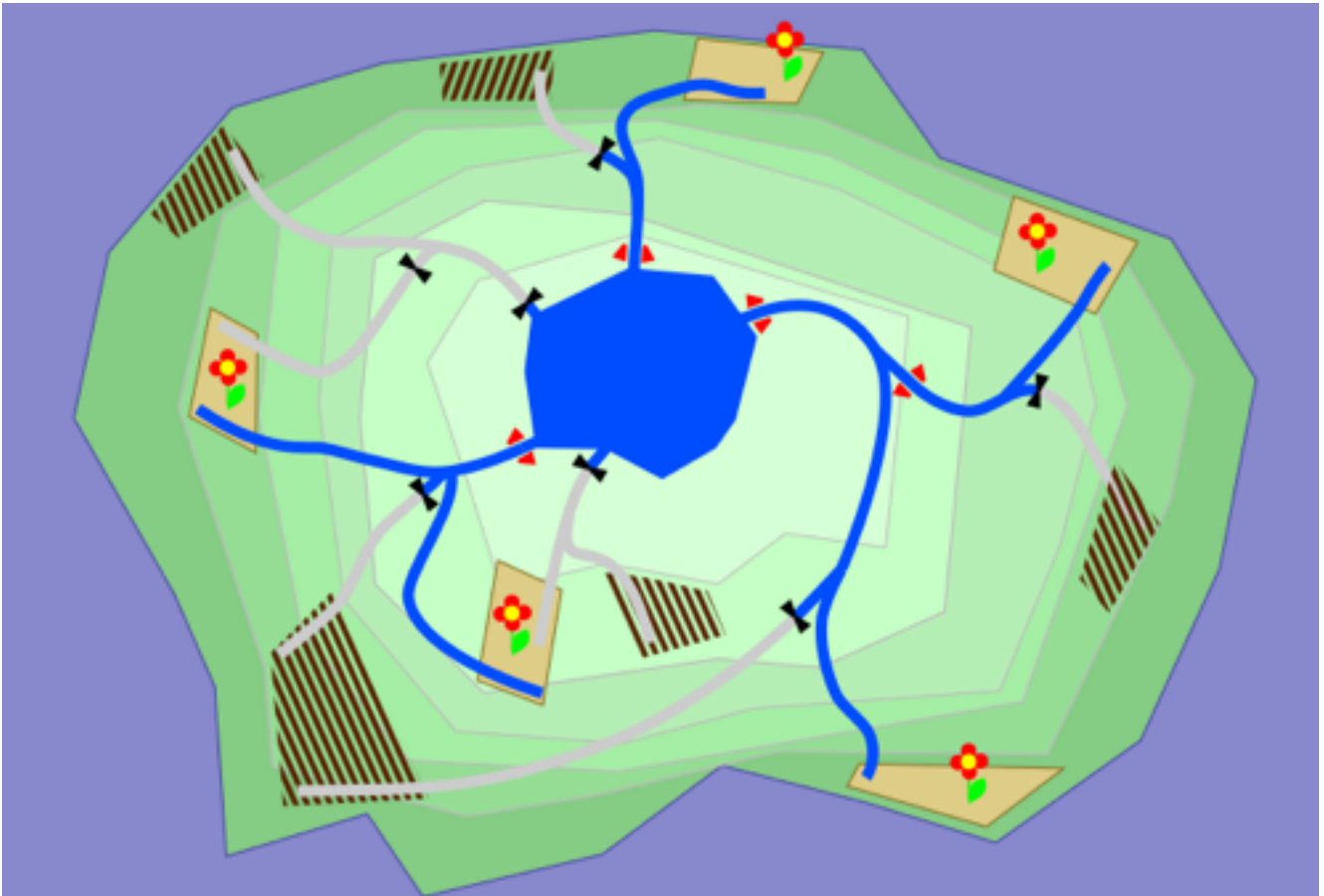


 Needs water

Must remain dry 

# Beaver Gates

Answer:



## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically*

The main difficulties here are the following:

- Some fields are watered by more than one canal
- Some canals water more than one field
- Our plan must be exact: you cannot water too many fields or too few

Although this particular problem is maybe not so hard to solve, if you have more fields, more canals and more connections, the task may become extremely difficult - even for a computer!

Knowing (or computing) how hard a task is even before you try to solve it is a very important part of computer science.



Three very fast beavers will compete in a cross-country run.

Mr. Brown will overtake one beaver when running uphill.

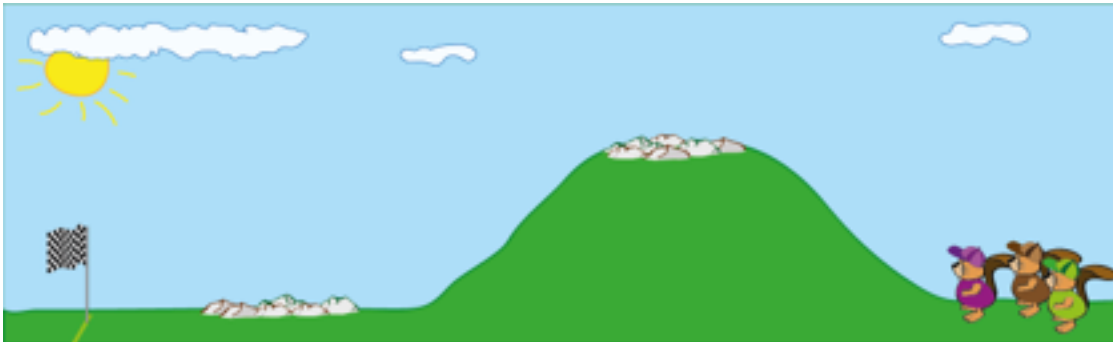
Mrs. Pink will overtake one beaver when running downhill.

Mrs. Green will overtake one beaver when running across rocks.



The terrain is shown in the picture: uphill, followed by some rocks, downhill and then some more rocks.

Mrs. Pink starts in the first position, followed by Mr. Brown and Mrs. Green.



**Question:**

In which order will the beavers finish the race?

- A. Mrs Pink, Mr Brown, Mrs Green
- B. Mr Brown, Mrs Pink, Mrs Green
- C. Mr Brown, Mrs Green, Mrs Pink
- D. Mrs Green, Mrs Pink, Mr Brown

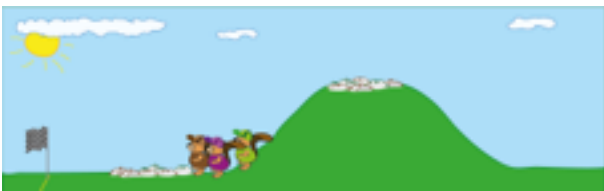
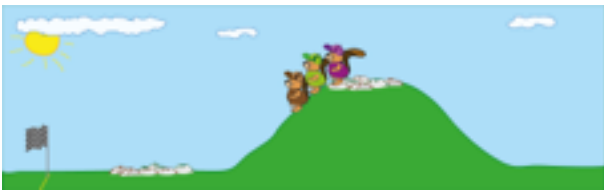
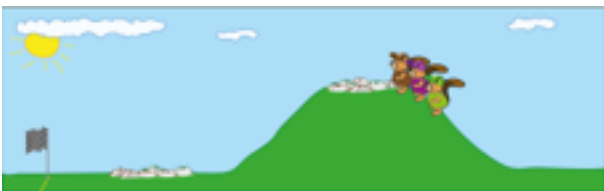
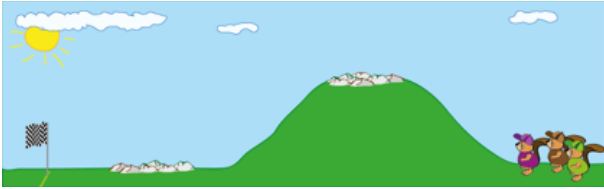


# Cross Country

## Answer:

(C) Mr. Brown, Mrs. Green, Mrs. Pink

## Explanation:



## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

Programmers must often look closely at how their programs run. This is especially true when the programs do not work well: in this case, programmers carefully go through and check the effect of each line of the program.

This task is similar. You are given some data – the sequence of runners. You have to “step through the program” - where the “steps” are uphill – rocks – downhill – rocks. You have to observe the effect of each step on the sequence and thus discover the “output” of the program, that is, the order at the end.



Stella the beaver loves to draw stars. She has devised a system for labelling her stars according to their shape. She uses two numbers:

A number of dots for the star.

A number indicating if a line from a dot is drawn to the nearest dot (the number is 1), the second closest dot (the number is 2), etc.

Here are four examples of Stella's labelling system:



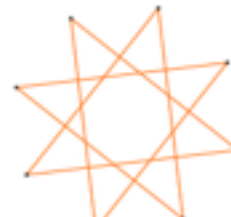
5:2



6:2



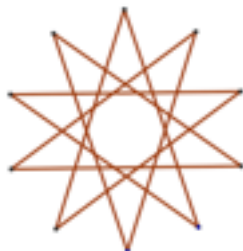
7:1



8:3

**Question:**

How would Stella label the following star?

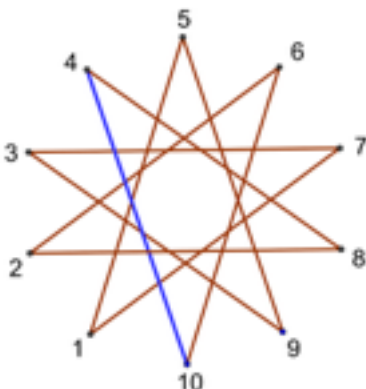


9:3 9:4 10:4 or 10:5

**Answer:**

10:4

**Explanation:**



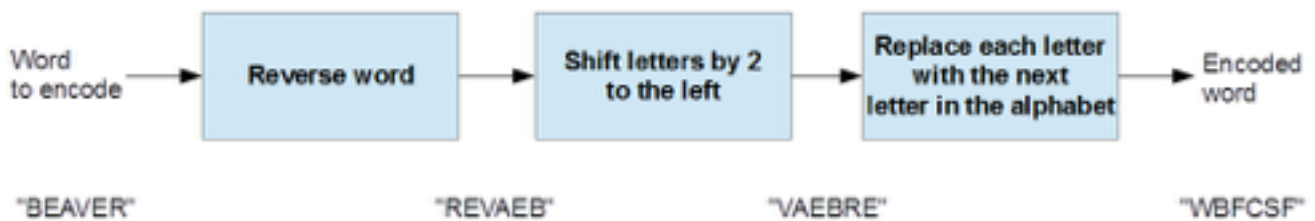
**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

Computers need simple representations of objects to be able to work with them. The fact that a complex and beautiful object such as a regular star polygon can be described by only two integers is an example of a simple representation.



Beaver Alex and beaver Betty send each other messages using the following sequence of transformations on every word.



For example, the word "BEAVER" is transformed to "WBFCSF".

Beaver Betty receives the encoded message "PMGEP" from beaver Alex.

### Question:

What did Alex want to say?

RIVER, KNOCK, FLOOD or LODGE

### Answer:

FLOOD

### Explanation:

The steps of the transformation, applied in the reverse order, are:

"PMGEP" → "OLFDO" → "DOOLF" → "FLOOD" That is:

- Replace each letter with the previous in the alphabet;
- Shift letters by 2 to the right;
- Reverse word.

The other answers are not correct.

### It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

The image in this task is part of a simple flowchart, that explains how to change a word step by step. Flowcharts are a way to describe algorithms. In this task the algorithm changes text so that nobody can understand it. This is called ciphering.



Three spotlights are used to light the theatre stage in the beavers' forest, 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.

This table 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 this 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.

### Question:

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

Drag the correct colour onto the block of the minute.

Black
Blue
Green
Cyan
Red
Magenta
Yellow
White

Minute 1
Minute 2
Minute 3
Minute 4

# Theatre

**Answer:**



**Explanation:**

The best way to approach this is to produce a table showing which lights were on when and what the result would be:

Time (mins):	1	2	3	4
Red light			Red	Red
Green light		Green		Green
Blue light	Blue	Blue	Blue	Blue
Stage colour:	Blue	Cyan	Magenta	White

**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically,*

The way colours can be constructed from three basic colours of lights is the RGB colour model. It is used, among many other places, in computer monitors and TV sets to show pictures. Pictures are made up of pixels, which are coloured as a combination of the three basic colours. It is an important principle of computer hardware and computer graphics.

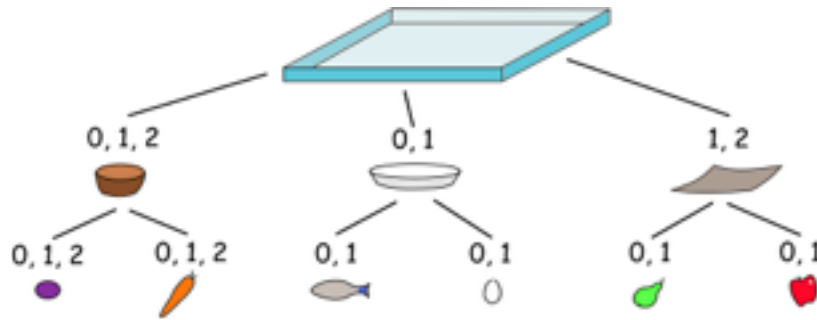
The task also involves an understanding of sequences of actions – in this case the sequence of switching particular light(s) on and off. It is an important part of algorithmic thinking. This is also an example of parallel execution of three independent sequences.



Hm, what to take for lunch today?

The cafeteria gives instructions on how to choose a Beaver lunch.

This is shown as a diagram:



Below the tray you see different types of food containers.

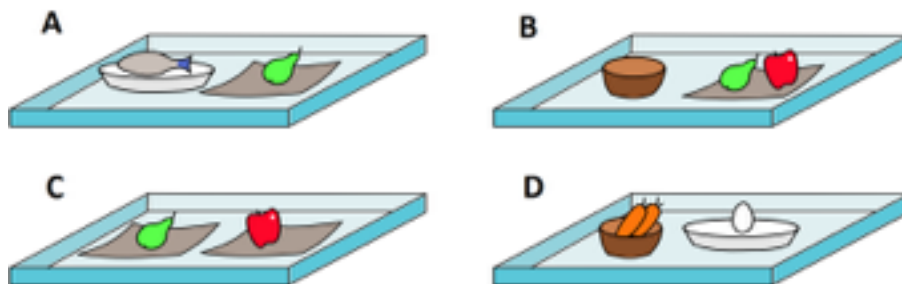
The numbers indicate how many containers of this type can be added to a tray.

Each container can only have food items put in it that are shown below it.

The numbers indicate how many food items of this type can be added to the containers.

**Question:**

Which of the following lunches is not a proper Beaver lunch?





# Beaver Lunch

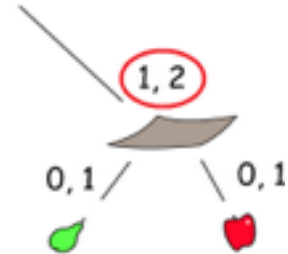
---

## Answer:

D is not a Beaver Lunch.

## Explanation:

D is not a beaver lunch, because there is no container of the third type on the tray. In the picture there are the numbers 1 and 2 written above the image of this container indicating that a beaver meal should have one or two of these.



## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically,*

The image defining the recommendation is an example of a certain type of diagram, called a tree. It looks a little bit like a tree upside down with the root on top. Programmers use diagrams like these to define the structure of aggregates. An aggregate is a complex object which consists of simpler parts. And each part may be composed of even simpler parts.



The beavers and dogs had a competition. In total nine animals took part.

The nine participants had the following scores: 1, 2, 2, 3, 4, 5, 5, 6, 7.

No dog scored more than any beaver.

One dog tied with a beaver.

There were also two other dogs that tied with each other.

### Question:

How many dogs took part in the competition?

2, 3, 5, 6 or 7

### Answer:

6

### Explanation:

First we arrange the scores in numerical order. Then we look for ties, there are two of these. One must be between two dogs and the other between a dog and beaver. If the two animals that score 2 points are the beaver and dog then the two animals scoring 5 points must be the tied dogs. This cannot be the case though because that would mean two dogs at least scored more points than a beaver. We can now see the boundary between beavers and dogs:

dogs 1,2,2,3,4,5,|5,6,7 beavers

Therefore 6 dogs took part in the competition

### It's Computational Thinking:

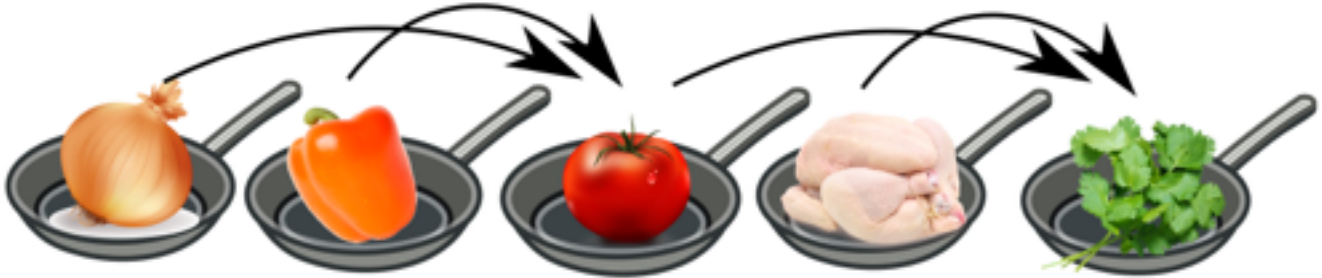
*Breaking down problems into parts, Interpreting patterns and models, Organising data logically*

When working with data, some organisation of them is necessary. This task requires us to understand how the data are ordered and how ordering rules are used. You also need to use some logic to solve this task.

Remember that no mathematics is necessary to solve this task. You can solve it even if there were letters instead of numbers: A, B, B, C, D, E, E, F, G.



Sergo the beaver loves to cook. His favourite meal is Chakhokhbili.



When cooking in the garden he uses a single gas burner. He performs the following actions after each other:

- |   |  |            |
|---|--|------------|
| 1 | Cook an onion  | 10 minutes |
| 2 | Cook a bell pepper   | 10 minutes |
| 3 | Combine the cooked onion and cooked bell pepper, add a tomato and cook this together | 20 minutes |
| 4 | Cook a chicken   | 30 minutes |
| 5 | Combine everything from steps 3 and 4, add some spices, and cook it all.             | 20 minutes |

In total Sergo needs 90 minutes to prepare his Chakhokhbili on a single gas burner.

### Question:

When Sergo cooks at home he has many gas burners available. He is able to use more burners so his meal is ready sooner.

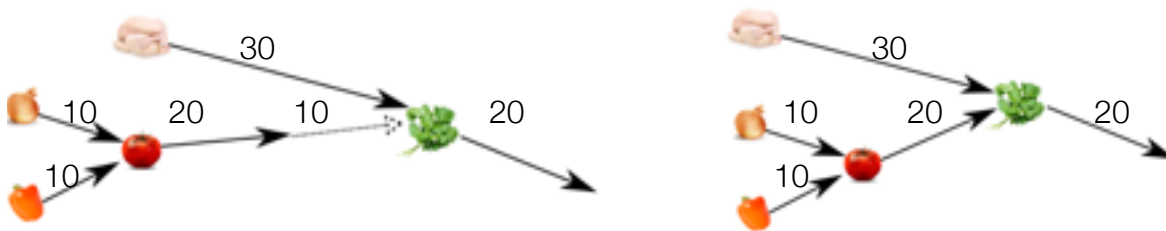
Which of the following statements is NOT correct?

- A. Sergo can reduce the cooking time by 10 minutes when using 2 burners
- B. Sergo can reduce the cooking time by 30 minutes when using 2 burners
- C. Sergo can reduce the cooking time by 40 minutes when using 3 burners
- D. Sergo can reduce the cooking time by 50 minutes when using 4 burners

## Answer:

D. Sergo can reduce the cooking time by 50 minutes when using 4 burners - False

## Explanation:



The left picture illustrates how to decrease the cooking time by 30 minutes (for answers A and B)

The right picture illustrates how to decrease the cooking time by 40 minutes (for answer C)

## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

In this task gas burners are computer resources such as processors. If you have only one resource, you should process your work sequentially and if you have more resources you can sometimes process the tasks in parallel.

Shortening the time is like structuring programming code to run as fast as possible given the amount of processors available. It is good practice to optimise code to be able to run as fast as possible. Parallel computing is a big field of research in computer science.



Edgar is looking for a new home to live in.

He searched the internet and found a perfect flat for a very good price.

He has sent an e-mail to Francis, who is selling the flat, and received a quick reply:

Hi,

Thank you for your interest in my flat.

Although I am not in town, I can send you the key to the flat so you can inspect it, but I need a security deposit of \$5.000,- beforehand.

To show my trustworthiness, I attach a copy of my ID.

Cheers,

Francis

Edgar is unsure what to do and is asking for your help.

### Question:

What would be your best advice?

- A. Pay the deposit. With the ID you can always go to the police if you don't get the deposit back.
- B. That is perfect. If you like the flat, you can keep the key right away.
- C. Don't pay the deposit, there is a high chance that this is a mail fraud.
- D. Pay the deposit, go and have a look and decide later on.

### Answer:

Response C

### Explanation:

Response C would be the best advice. The copy of the ID could be "Photoshopped". You will not be able to meet the person to verify the ID. Statements 1 and 2 are not good as there is a high chance of not even receiving the key. Statement 4 is not good since the authenticity of the ID can't be proven.

### It's Computational Thinking:

*Although this question doesn't really use computational thinking strategies from the Australian Curriculum it does highlight the need for awareness of safety whilst working in an online environment which would help address some of the requirements for teaching the Year 9-10 Band Content Descriptor: Create interactive solutions for sharing ideas and information online, taking into account safety, social contexts and legal responsibilities (ACTDIP043)*

The Internet can be used to hide ones true identity and provides anonymity. Criminal people use this mechanism to get money from naive people. Very often spelling mistakes or high money values are within such emails and should raise awareness from the user.



All members of a beaver family have abilities.

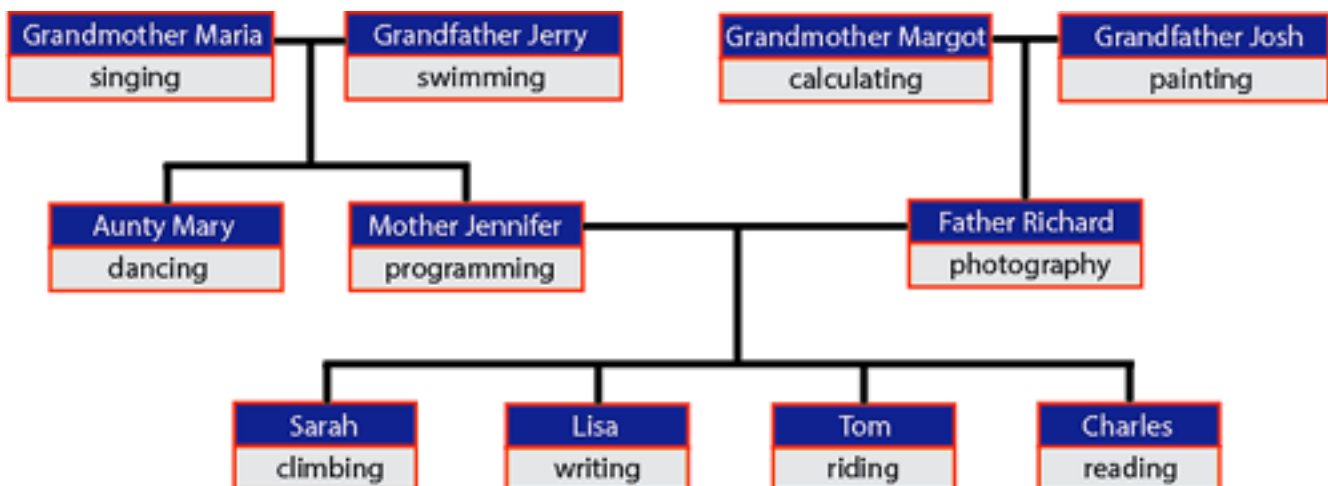
- A daughter inherits all her abilities from her mother.
- A son inherits all his abilities from his father.
- Each family member also has one extra ability.

The diagram below shows the relationships between the beavers. It also shows the extra ability for each beaver.

Examples:

Mother Jennifer has inherited the ability to sing from Grandmother Maria, and she also has the ability to program.

Lisa inherits two abilities from her mother and also has the ability of writing. This means she can write, program and sing.



### Question:

Look at the diagram above. Which of these answers is true?

- Tom's abilities are riding, painting and photography.
- Sarah has abilities in reading, programming and singing.
- Tom inherits from Grandmother Margot the ability to calculate.
- Aunt Mary has abilities in dancing and swimming.

**Answer:** Please refer to page 49

# Irrigation System

Age Group: Difficulty  
9+10: A

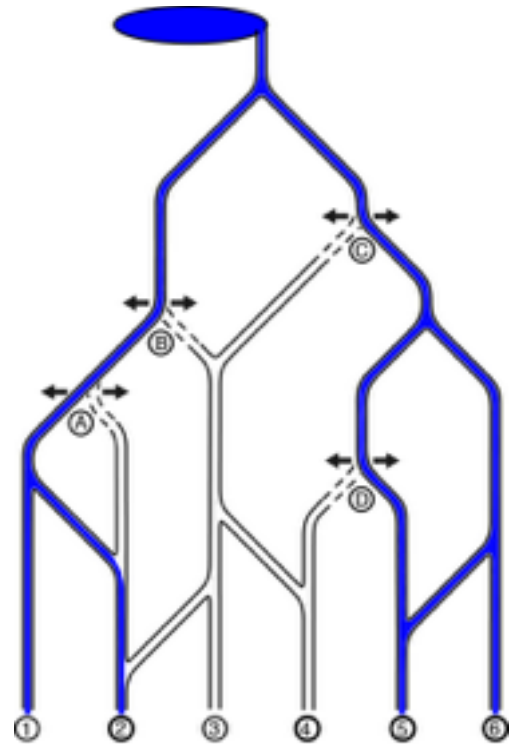


The beavers have created a clever irrigation system for their fields. The water flows from a lake at the top of the hill all the way down to the fields numbered 1 to 6 at the bottom.

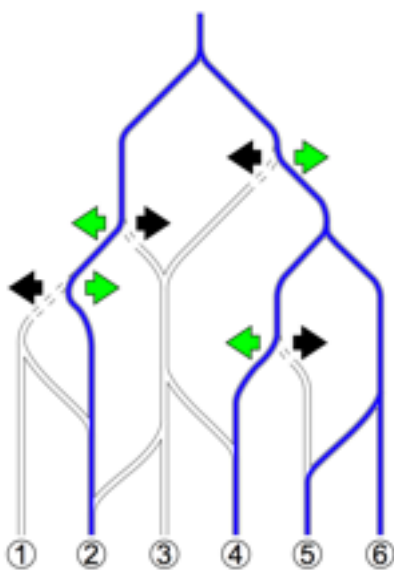
Along the water canals, the beavers have installed four water gates A, B, C and D, where the water can only flow either to the left or to the right.

## Question:

Click on the arrows, so that only the fields numbered 2, 4, 5 und 6 are irrigated.



## Answer and Explanation:



## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

The irrigation system behaves like a directed graph in graph theory. The graph shape is very similar to a tree with a root node and several leaves but in this graph there are directed connections between several vertices, which would not occur in a tree.

The water source forms the root of the graph and the crop fields are the leaves. If a node is connected to the root, water will flow there. Therefore, fields that need to be irrigated need to have at least one connection to the root node and fields that do not need to be irrigated must not have a connection.





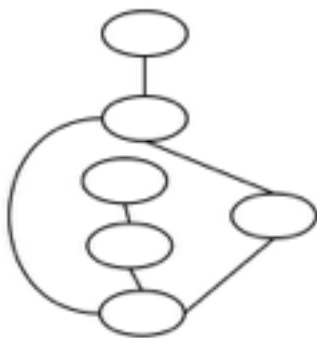
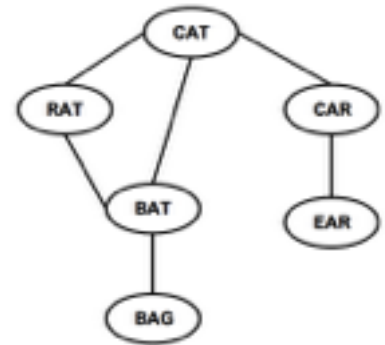
For his homework, Thomas had to write words on cards and connect them with rubber bands.

The teacher told him to connect any two words that differ by exactly one letter.

Thomas did this, as you can see in the picture on the right.

When Thomas returned from having a break he got a surprise.

Peter, his little brother, had erased all the words!



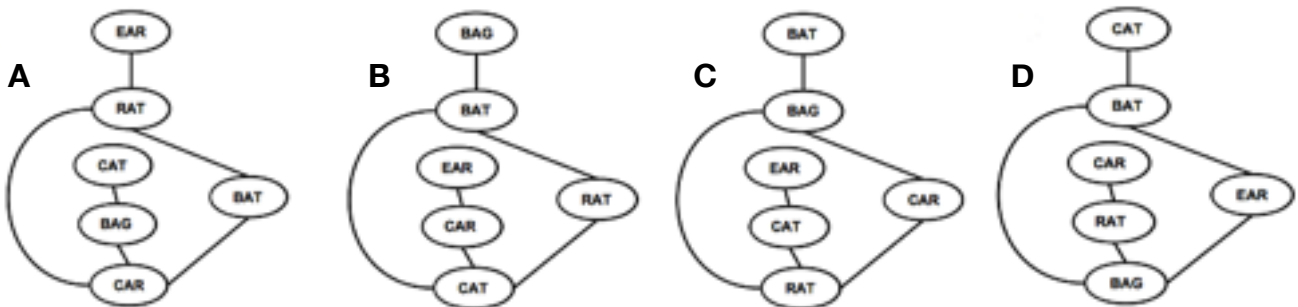
Also, the cards were completely mixed up, as you can see in the image on the left.

Importantly, the rubber bands still connected them as before.

Thomas was sure he could put the words back in the correct place.

**Question:**

Which of the pictures below contains the words in exactly the right places?



**Answer:**

B

**Explanation:**

We can proceed by counting the edges going from each node. There are 2 nodes with 3 edges, 2 nodes have two edges and 2 nodes have 1 edge. There is only one node with one edge connected to a node that has two edges. So we have identified the node for “EAR” and “CAR”. We can continue with this method ruling out the wrong answers as we proceed.

**It’s Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically.*

This question is about graphs. A graph is a set of objects, where some pairs of objects are connected

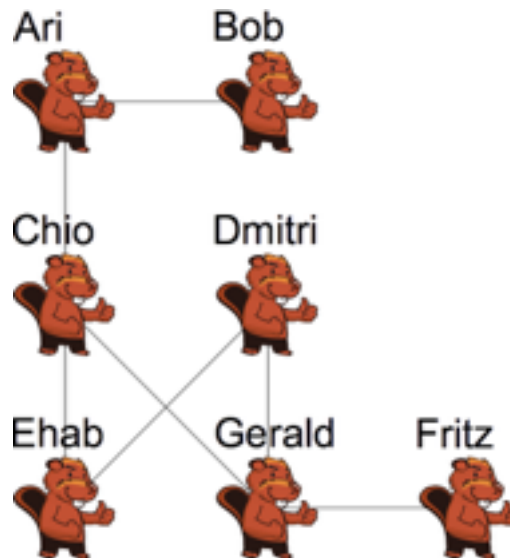


Seven beavers are in an online social network called Instadam.

Instadam only allows them to see the photos on their own and their friends' pages.

In this diagram, if two beavers are friends they are joined by a line.

After the summer holidays everybody posts a picture of themselves on all of their friends' pages.



**Question:**

Which beavers' picture will be seen the most?

Ari, Bob, Chio, Dmitri, Ehab, Fritz or Gerald

## Answer:

The correct answer is Chio.

## Explanation:

In order to find the beaver whose picture gets seen by most beavers, you have to count the beavers that are at most two steps away. The beavers one step away are those on whose page the pictures will be posted and the beavers two steps away are those who can see these pages. Of course any beaver can only be counted once.

The following table summarises the info and helps us to see whose picture will be seen the most.

Beaver	Direct Friends	Friends' Friends	Total
Ari	Bob, Chio	Ehab, Gerald	4
Bob	Ari	Chio	2
Chio	Ari, Ehab, Gerald	Bob, Dmitri, Fritz	6
Dmitri	Ehab, Gerald	Chio, Fritz	4
Ehab	Chio, Dmitri	Ari, Gerald, Fritz	5
Fritz	Gerald	Chio, Dmitri	3
Gerald	Chio, Dmitri, Fritz	Ari, Ehab	5

## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

Many social networks use larger and more complicated versions of this concept. It is not always obvious that by posting something on a friend's page, it might be available to people other than the close friend.

Social networks themselves are incredibly powerful tools in today's world. Computing statistics on their users and their pages is useful to marketing departments and anyone else trying to understand a person or group of people.

Instadad could also be interpreted as a model of a miniature internet, with the beavers being websites and friends as pages "linked to". Search engines typically rank these websites by some measure of popularity or importance, at least by the number of links to and from the website.

A widely used way to find the result by using a computer is to use the flood fill algorithm which can cope with systems with more than the two iterations in this example.



The Stack Computer is loaded with boxes from a conveyer belt. The boxes are marked with a Number or an Operator (+, -, \* or /).

The computer is loaded until the top box is a box marked with an operator. This operator is then used on the two boxes below it. The three boxes are then fused into one single box and marked with the outcome of the calculation.

In the Stack Computer, calculations are entered in a different way to a normal calculator.

Examples:

2+3 must be entered as 2 3 +

10-2 must be entered as 10 2 -

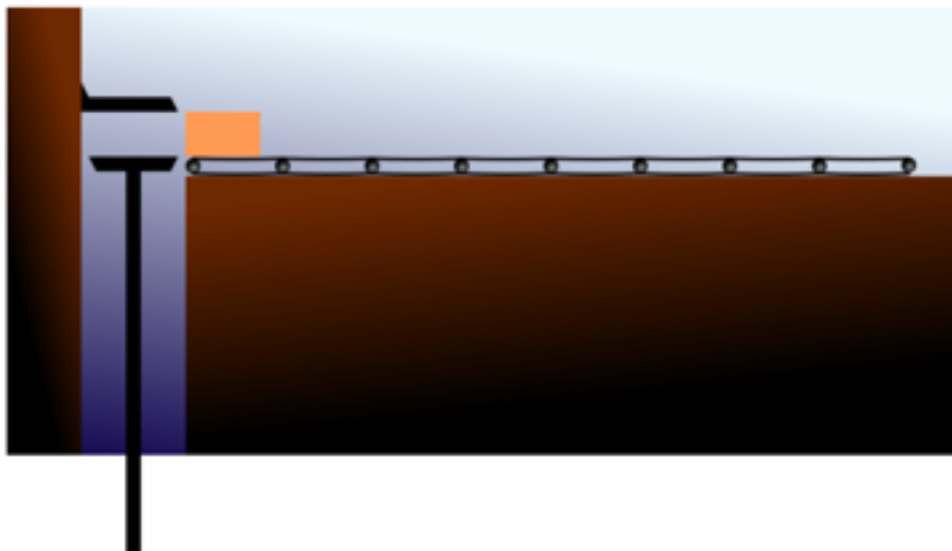
5\*2+3 must be entered as 5 2 \* 3 +

5+2\*3 must be entered as 5 2 3 \* +

(8-2)\*(3+4) must be entered as 8 2 - 3 4 + \*

### Question:

How should the following computation be entered:  $4*(8+3)-2$ ?





## Answer:

The correct answer is  $4\ 8\ 3\ +\ *\ 2\ -$

However, the following answers are also acceptable as they all produce the correct output.

$4\ 3\ 8\ +\ *\ 2\ -$

$8\ 3\ +\ 4\ *\ 2\ -$  (a very sensible answer)

$3\ 8\ +\ 4\ *\ 2\ -$

These inputs all lead to the same result, even though the order of the operators and operations are not the same as intended in the given expression.

## Explanation:

From left to right, we first have  $4*(8+3)$ , so we need 4 and the result of  $8+3$  on the stack. We achieve that by writing

$4\ 8\ 3\ +$

We then have 4 and 11 on the stack, so we add a  $*$  to multiply the two numbers. We now have 44 on the stack, we add a 2 and a  $-$  for the final subtraction.

## It's Computational Thinking:

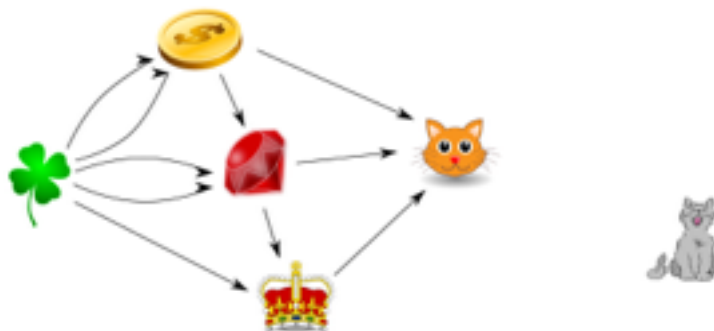
*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

The usual notation for arithmetic expressions is not the easiest to understand for a computer, or rather, it takes a more complicated program (algorithm) to process such expressions. However writing a program to analyse expressions in postfix notation (as done by this machine) is much much easier. This is one reason why on some early handheld calculators this notation had to be used. Another reason is, that the postfix notation does not require any brackets, no matter how complex the expression.



Beaver the Alchemist can convert objects into new objects. He can convert:

- Two clovers into a coin
- A coin and two clovers into a ruby
- A ruby and a clover into a crown
- A coin, a ruby, and a crown into a kitten.



After an object has been converted into another object, it disappears immediately.

## Question

How many clovers does Beaver the Alchemist need to create one kitten?

5, 10, 11 or 12

## Answer:

The answer is 11.

## Explanation:

We can see the conversion as follows:

coin = 2 clovers

ruby = 2 clovers + 1 coin = 4 clovers

crown = 1 ruby + 1 clover = 4 clovers + 1 clovers = 5 clovers

kitten = 1 coin + 1 ruby + 1 crown = 2 clovers + 4 clovers + 5 clovers = 11 clovers






## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

This task demonstrates how graphs can be used to represent dependencies between items. A graph is a data structure that is used a lot in computational thinking to demonstrate relationships. Graphs also make it easier to visualise a task compared to just reading the descriptions of the relationships in text.



Two beavers live in lodges separated by a large forest. They decide to send messages to each other by shooting fireworks into the sky above the trees. Each message is a sequence of words, though the beavers only know five different words. The beavers can shoot two types of fireworks, one after the other, and know the following codes:

Word	Code
Log	
Tree	
Rock	
River	
Food	

For example, to send the (rather strange) message "food, log, food", a beaver would shoot:



### Question?

How many **different** meanings can the following sequence of fireworks have?



0, 1, 2, 3, or 4

**Answer:** Please refer to Page 55





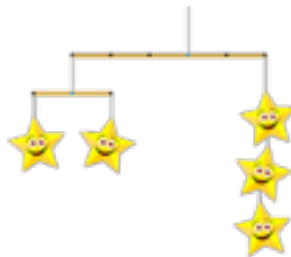
A mobile is a piece of art that hangs from a ceiling. You may remember one hanging from the ceiling in your bedroom.

A mobile consists of sticks and figures. Each stick has a few points to which figures or other sticks may be attached.

Also, each stick has a hanging point, from which it is attached to a stick further above (or to the ceiling).

The following example mobile can be described using these numbers and brackets:

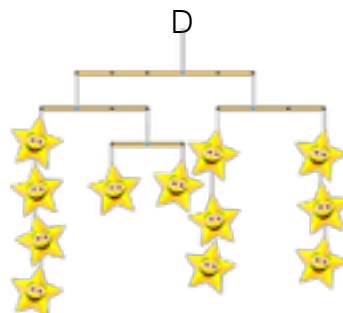
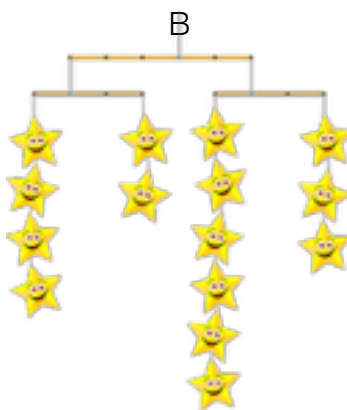
$(-3 (-1 1) (1 1)) (2 3)$



**Question:**

Which of the following mobiles could be constructed using these instructions:

$(-3 (-1 4) (2 (-1 1) (1 1))) (2 (-1 6) (2 3))$



**Answer:** Please refer to Page 56



The teacher in the beaver school wants to give some material to his students.

He found a portal with a scanned book which declares in its front page that it should be distributed according to a “Creative Commons License” (CC-BY-ND) that makes everyone free to share, copy and redistribute the material in any medium or format for any purpose, even commercially, provided that appropriate credit is given.

The license also specifies that if one remixes, translates, or builds upon the book, the modified book may not be distributed.

**Question:**

Which of these actions is not permitted under the terms of this license?

- A. Selling copies of the book to students
- B. Translating the book, keeping the translated copy for himself
- C. Giving the students one chapter of his translation of the book
- D. Putting a scanned copy of the book on the school website

**Answer:**

C is not permitted and so is the answer to this problem.

**Explanation & It's Computational Thinking:**

Although this question doesn't really use computational thinking strategies from the Australian Curriculum it does highlight the need for awareness of ethics and respect for others' rights whilst working in an online environment which would help address some of the requirements for teaching the Year 9-10 Band Content Descriptor: Create interactive solutions for sharing ideas and information online, taking into account safety, social contexts and legal responsibilities (ACTDIP043)

Building on the learning from Years 9 and 10, students in Years 11 and 12 should continue to maintain high ethical standards.

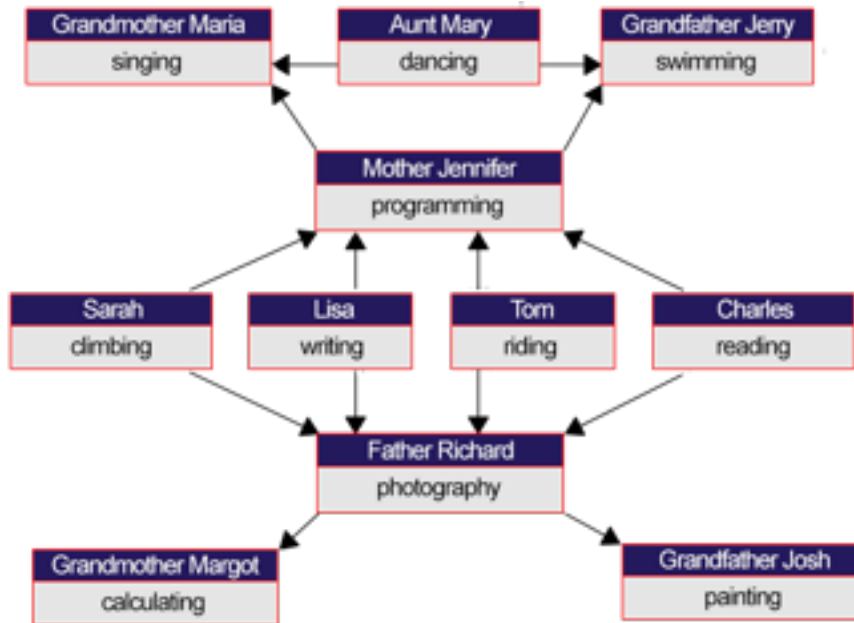
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The Year 11+12 students had the same question but with a possibly more difficult to interpret diagram, shown here:



### Answer:

Statement A is correct

### Explanation:

Statement A is correct, since Tom inherits painting from his grandfather and photography from his father.  
Statement B is not correct, because Sarah does not inherit reading from her brother Charles.  
Statement C is not correct, because Tom can not inherit abilities from his grandmother.  
Statement D is not correct, because Aunt Mary does not inherit swimming from her father.

### It's Computational Thinking:

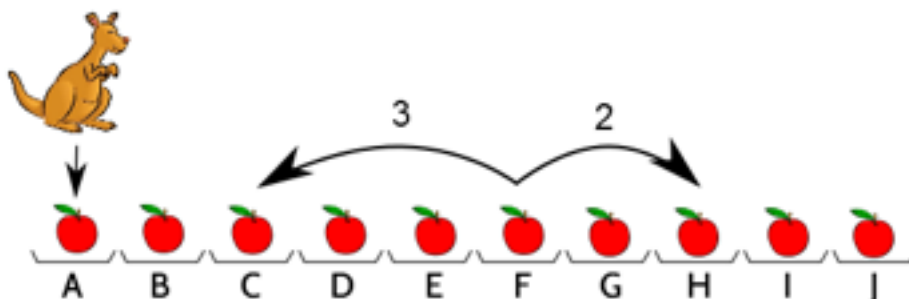
*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

Inheritance is an important concept in object oriented programming. Parts of software systems can be reused and expanded. In this case abilities are like parts of software and are inherited and enriched with additional abilities.

In our task inheritance is different from programming because not everything is inherited.



There are 10 plates in a row. There is one apple on each plate.



Thomas the kangaroo loves to jump. First, he jumps onto the leftmost plate with the letter A. On each single jump after this, he either jumps forward two plates, or backwards three plates. (An example of the two possible jumps from one plate is shown with arrows in the picture.)

Thomas only jumps onto plates with an apple.  
If he jumps onto a plate, he collects the apple from it.

**Question:**

If Thomas collects all 10 apples, which apple does he collect last?

A, B, C, D, E, F, G, H, I or J

**Answer:**

Plate 1

**Explanation:**

Thomas can collect all ten apples in the order 1, 3, 5, 2, 4, 6, 8, 10, 7, 9.

This is the only sequence of jumps that allows Thomas to collect all the apples. Why? To begin, Thomas must jump on plates 1, 3 and then 5 because otherwise he jumps to the left of the first plate. Next, he must jump to plate 2 because he can only get to plate 2 from plate 5 and he will not return to plate 5 later. The same kind of reasoning can be used to determine the only possible solution.

**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

One way to solve this problem is to consider all possible sequences of plates and look for one that consists only of valid jumps. Each possible sequence is called a permutation and there are many of them. So this approach, which is called a brute-force or exhaustive search, takes a lot of time.

Another approach is to build a permutation one plate at a time. Once you figure out that a permutation or the start of a permutation is not valid (such as determining that the second plate cannot be anything but plate 3), you can remove the last plate(s) and continue building new permutations. This is called backtracking and if you can rule out many permutations early in your search, you can find a valid permutation much faster. This short-cut is called pruning.

One way to look at this problem is to view it as a graph. The plates are vertices and we join two plates by an edge if Thomas can jump between them. The task involves finding a path moving along edges that visits every vertex exactly once. This is called a Hamiltonian path. In general, it is very hard to find such a path. However, in this case, the graph is small and has special properties.

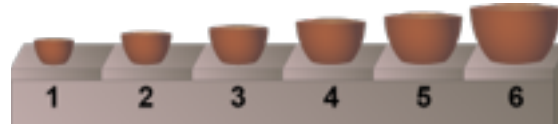
The general problem of finding a Hamiltonian path is known to be NP-complete which means that it belongs to a collection of very important problems for which we do not have efficient solutions. Interestingly, we know that if somebody finds an efficient solution to one of these important problems, then we instantly have a way to solve every one of these important problems efficiently.



A factory produces sets of 6 bowls of different sizes. A long conveyor belt moves the bowls one by one, from left to right.

Bowl production places the 6 bowls of each set onto the conveyor belt in a random order.

Before packing the bowls, they need to be sorted to look like this:

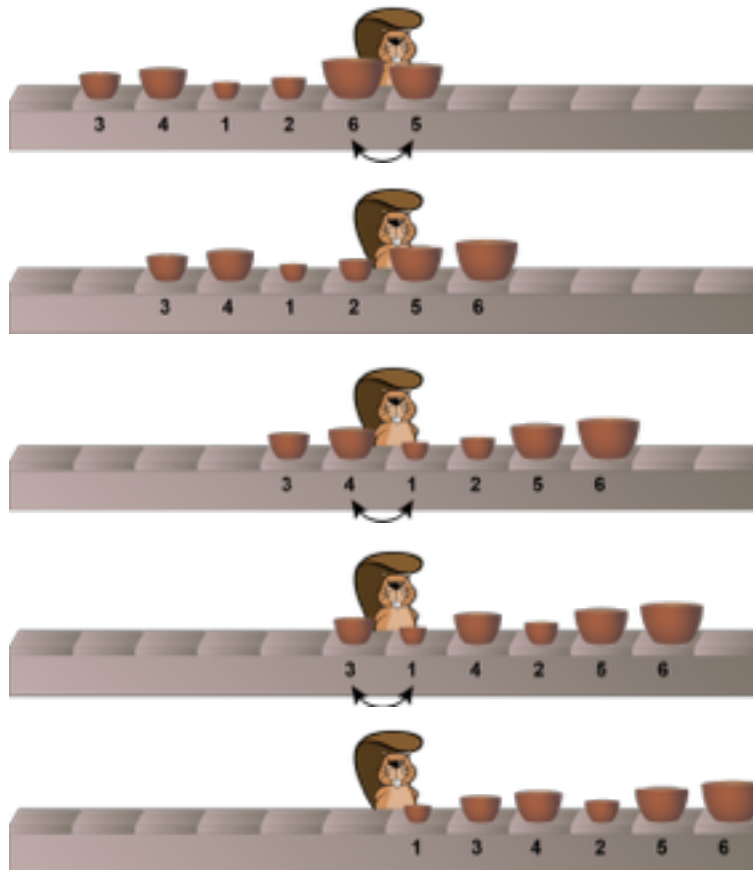


To help with the sorting, the factory places workers along the conveyor belt.

When a set of bowls passes a worker, the beaver will swap any two neighbouring bowls which are in the wrong order.

The worker will keep doing this until the set of 6 bowls has finished passing.

See how the order of a set of bowls changes as it passes one worker:



**Question:**

How many workers should be put along the line to sort the set of bowls on the right?



**Answer:**

4

**Explanation:**

As shown in the question, the original order of the set of bowls is: 5 6 3 2 1 4

Remember that the swapping of neighbouring bowls happens from right to left.

After passing a first worker, the order of the bowls is: 1 5 6 3 2 4 (4 swaps, all with bowl 1)

After passing a second worker, the order is: 1 2 5 6 3 4 (3 swaps, all with bowl 2)

After passing a third worker: 1 2 3 5 6 4 (2 swaps, all with bowl 3)

After passing a fourth worker, the set of bowls is sorted: 1 2 3 4 5 6 (2 swaps, all with bowl 4)

**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

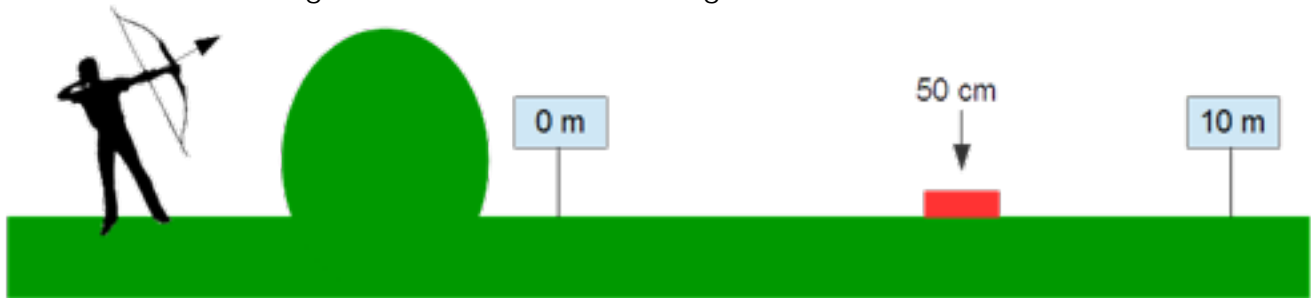
Typically, automatic processing of data (which is what computational thinking is mostly about) is much easier when data is arranged according to some criteria – when it is sorted. Much effort has been spent by Computer Scientists on investigating sorting algorithms. The method for sorting sets of bowls that is described in this task is called a “bubble sort”. This sorting algorithm steps through a list of objects again and again, swapping any neighbouring objects which are in the wrong order. The list is sorted when no swap occurs during a pass through the list.

Bubble sorting is quite easy to understand compared to other sorting algorithms. Unfortunately, it is not very efficient. For sorting 1000 items, a bubble sort may use up to half a million steps in the worst case. Better sorting algorithms would use only about 10 000 steps.



Arnaud would like to reach a target with his arrow. He can adjust the arc to shoot an arrow in a range between 0 m and 10 m.

The position of the target is unknown, but after each shoot, his friend Marc tells Arnaud whether the arrow reached the ground before or after the target.



## Question?

Given that the target has a width of 50cm, what is the minimal number of arrows needed to be sure to hit the target, no matter where it is located?

3, 4, 5 or 6

## Answer:

It should require 5 arrows

## Explanation:

The best strategy is to use a binary search. The first shot is done at 5 m, which splits the shooting area into two 5-metre wide blocks. Either the target has been reached, or it is located in one of the two blocks. The second shot is done at either 2.5m or 7.5m, breaking the shooting area into two 2.5-metre wide blocks. The target may still be missed. The third shot will reduce the shooting area to 1.25-metre blocks, the fourth shot to 0.625-metre blocks. The fifth shot reduces the shooting area to 0.3125-metre blocks, and will surely hit the target!

## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

This task introduces to binary search, that is an algorithm to find an element in  $O(\log n)$  time complexity, reducing the search space by 2 at each step.



# Fireworks (hard)

Age Group: Difficulty  
11+12: C



The year 11+12 students had the same question but there was a free choice of input rather than a multi-choice question.

## Answer:

The correct answer is 4.

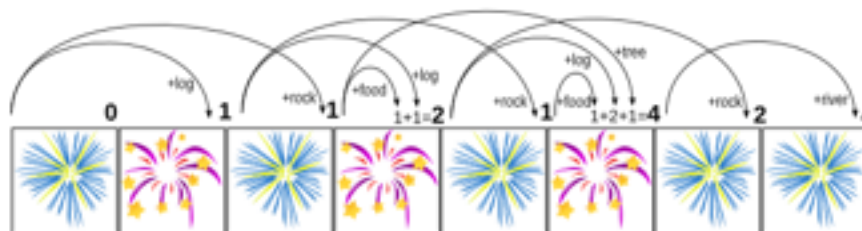
## Explanation:

The message could mean any of the following:

- log, rock, food, river
- log, log, log, river
- rock, tree, river
- rock, food, log, river

To convince yourself that there are no more possibilities, you can systematically count them:

- Start with the first firework. It is not a message, so you can write a zero on it.
- The first two fireworks can only mean log. Write number one next to the second firework.
- We are at the third firework. It can have a meaning of any shorter sub-sequence plus one new word. Yet we see that there is no way to prolong the previously examined sequences (of length 1 and 2), so we only have one possible meaning (rock) and write 1 to the third firework.
- The fourth firework is finally somewhat interesting. It can either add the word log to the first two fireworks, or food to the first three fireworks, as shown by the arrows below. So we sum the two numbers at the 2nd and 3rd firework and write it to the 4th ( $1+1=2$ ).
- We proceed applying the same idea to each firework to the right. We look one, two and three fireworks back. If those shorter messages can be prolonged with a correct word, we mark this fact with an arrow. Then we just sum the numbers "brought" by the arrows to the currently examined firework.
- At the last firework, we will have the number of all possible meanings.



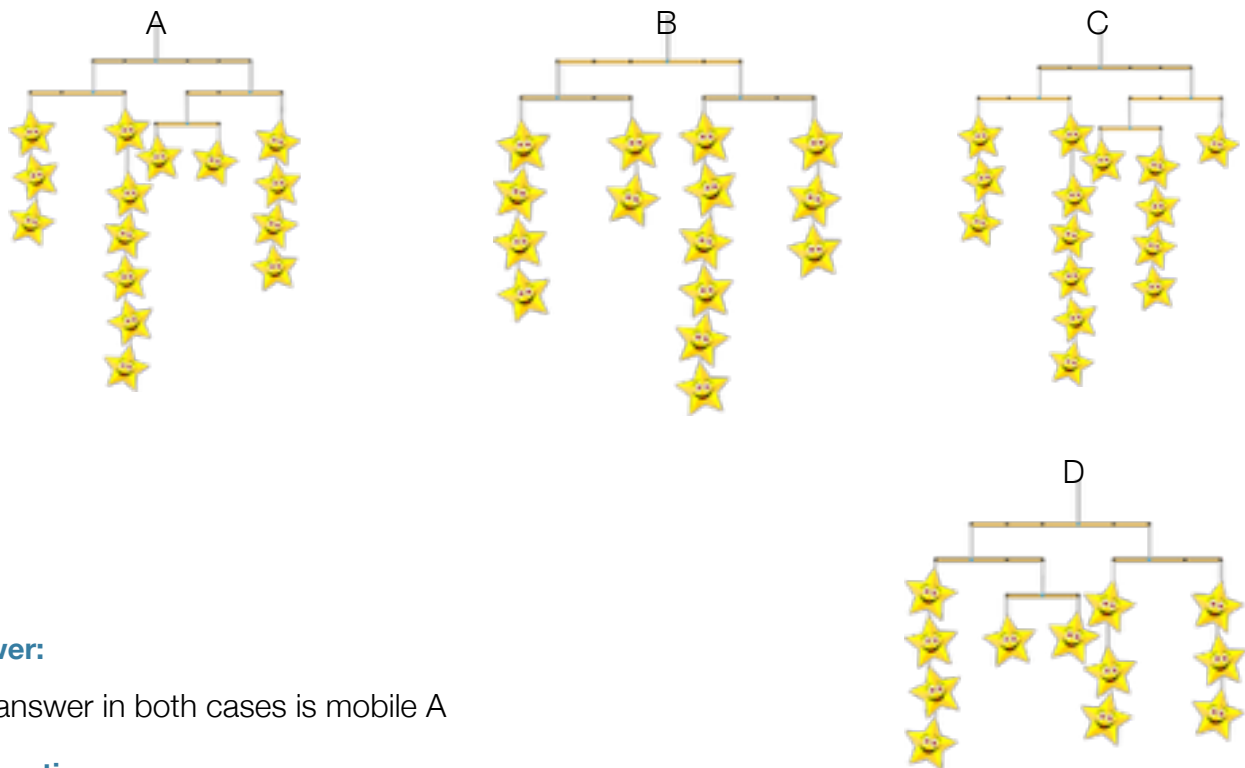
## It's Computational Thinking:

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

The process of building a solution systematically, step by step, using the previous steps like this is called dynamic programming. It makes the process much easier – just imagine trying to find all the full meanings of the message right away!

All digital information is represented using binary. That is, it consists of only the bits 0 and 1. Only longer combinations of 0 and 1 ("words" in this task) allow us to use more than two different meanings. But we also want to avoid ambiguity in our messages.

Most standard codes use the same number of bits per word, so there is only one meaning to each message. But if some word is used very often and some rarely, such code generates needlessly long messages. It is then useful to have shorter codes for frequent words (like "food") and longer codes for less frequent words (like "rock"). Of course you can be smarter than the beavers in our task: If you generate a prefix code the messages will only have one meaning. This trick of shortening frequent data chunks without introducing ambiguity is used in data compression.



**Answer:**

The answer in both cases is mobile A

**Explanation:**

From the sample mobile, we can conclude the following about how a mobile is described: A structure that is hanging from a stick is described by an opening bracket; the stick position where it is hanging from (with the hanging point of the stick equal to 0); the descriptions of its parts; and a closing bracket.

Sticks (including the uppermost one) are described by describing the structures hanging from it. Figures are described by how many of them are hanging from each point.

In the hard version it needs to be additionally realised that this 2D representation does not help us to see that mobiles can spin. It can be very hard to avoid jumping to conclusions when analysing systems!

**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically*

The structure of a mobile has an interesting property: If you detach a stick (except the uppermost one) from a mobile, you have a mobile again, with the detached stick being the uppermost stick now. That is, the parts of a mobile are constructed in the same way as the full mobile is constructed. If a single figure is considered as a (very basic) mobile, mobiles may be defined very briefly, as follows: A mobile is either

- (a) a single figure, or
- (b) a stick with one or more mobiles attached to it.

That is, in order to define a "mobile", we use the term "mobile" itself.

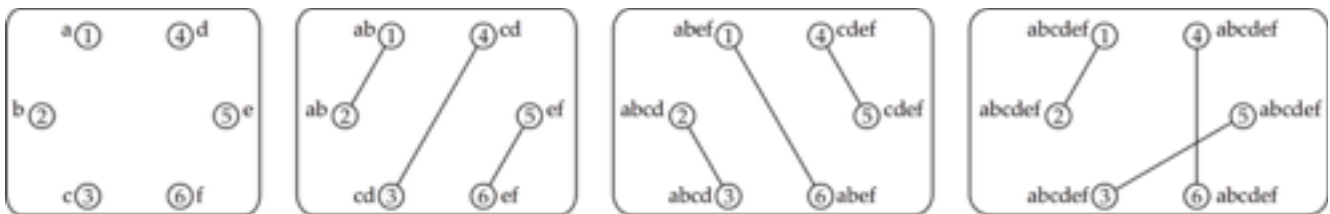
In computational thinking, such structures and their definitions are called recursive. With computer programs, recursive data structures may be assembled and processed with only a few lines of code thanks to the brevity of their definitions.



Every Friday, six spies exchange all the information they have gathered during the week. A spy can never be seen with more than one other spy at the same time. So, they have to have several rounds of meetings where they meet up in pairs and share all the information they have at that point.

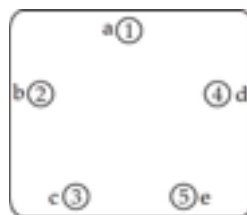
The group of 6 spies needs only three rounds to distribute all their secrets:

Before the meetings each spy holds a single piece of information. (spy 1 knows 'a', spy 2 knows 'b', etc.). In the first round spies 1 and 2 meet and exchange information so now both know 'ab'. The diagrams show which spies meet in each round with a line. It also shows which pieces of information they all have. After three rounds all information has been distributed.



**Which of the following statements is true?**

After an international incident one spy has stopped attending the meetings. What is the minimum number of rounds needed for the five remaining spies to exchange all information?



**Answer:**

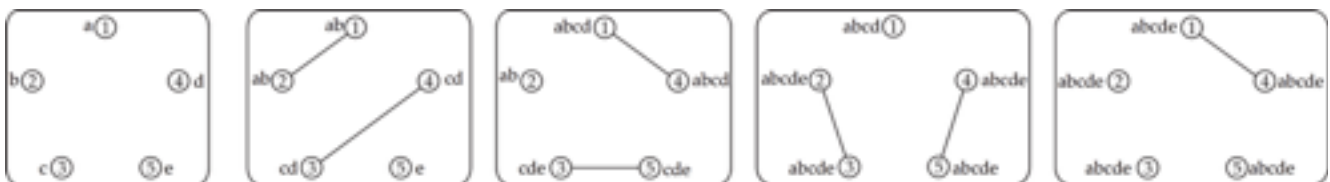
The correct answer is 4

**Explanation:**

This is unexpected! The obvious answer is three (or less?) since we have one spy less. This is even stranger if we consider that four spies would quite obviously exchange the information in two rounds.

However, unsuccessful attempts at solving the task soon show us the root of the problem: since the number of spies is odd, one of them is “inactive” in every round. Say, that spy number 5 does not participate in the first round, but he participates in the second. Thus in the second round, only two spies will know his piece information (e). In the third round, these two spies will meet two other spies, so after three rounds (only) four spies will know e. The fourth round is needed to spread this information to the fifth.

Therefore, we proved that at least four rounds are needed. To show that they also suffice, we construct a scheme with four rounds:



**It's Computational Thinking:**

*Breaking down problems into parts, Interpreting patterns and models, Organising data logically, Designing and implementing algorithms.*

When computers exchange information, they often exchange the data in pairs. Sometimes a problem involving how to share information along a whole network in the shortest time possible could arise. So computer scientists need to solve problems similar to this task. This problem is also known as the gossip problem (<http://mathworld.wolfram.com/Gossiping.html>). You can try to solve it for different numbers of spies and you might discover an interesting rule.

The solution of the problem was first solved – and the general rule described – in 1975. This and many similar problems occur in different areas of computer science especially those involving exchange of data, communication networks and cryptography.

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