UNIVERSITY OF WATERLOO

The CENTRE for EDUCATION in MATHEMATICS and COMPUTING

2022 Beaver Computing Challenge (Grade 9 & 10)

Questions
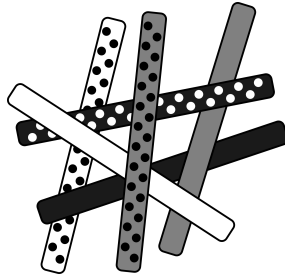
Part A
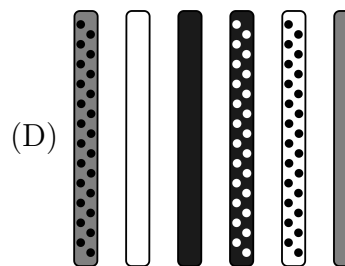
Pick Up Sticks

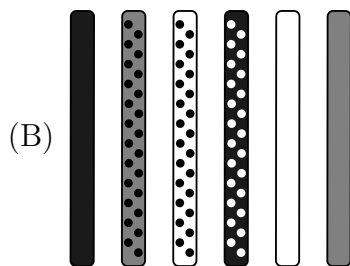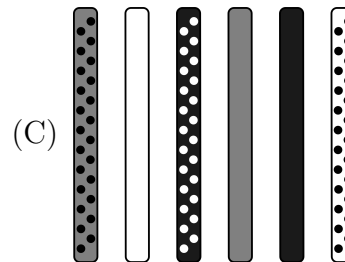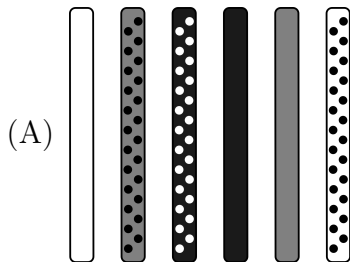Ana drops six sticks on a table as shown.

Then she picks all the sticks up according to the following rules:

1. Pick up one stick at a time.

2. Only pick up a stick if no other stick is on top of it.

Question

In which order did Ana pick up the sticks?


(A)

(B)

(C)

(D)

Lost In Space

Story

The mission to explore planet Castor was a success, except for the astronauts losing their personal belongings!

A self-driving robot was sent back to Castor in order to collect all the missing items. The robot can only drive north ($\uparrow$), south ($\downarrow$), east ($\rightarrow$), and west ($\leftarrow$). The robot is currently located in the first column on the third row and it has detected the location of seven lost items as shown:
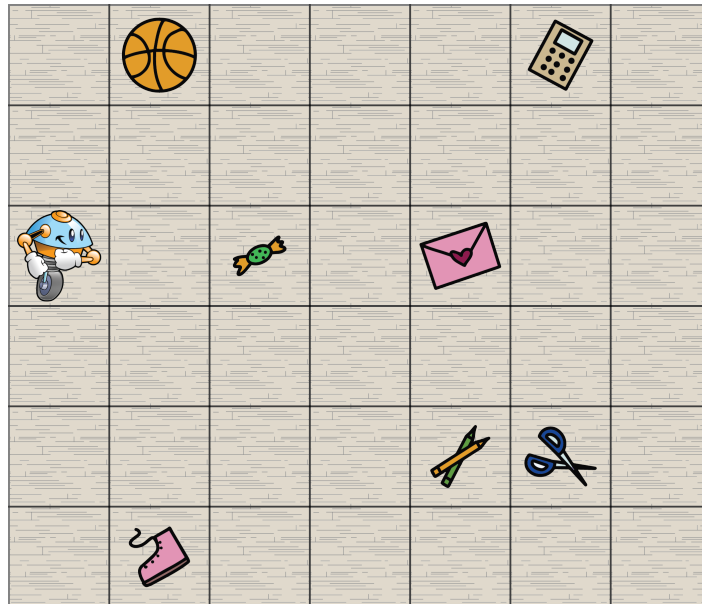
The robot is programmed to identify the item it can get to by driving through the least number of cells. Then it moves to the cell containing that item, and picks the item up. The robot repeats this program until all detected items have been picked up.
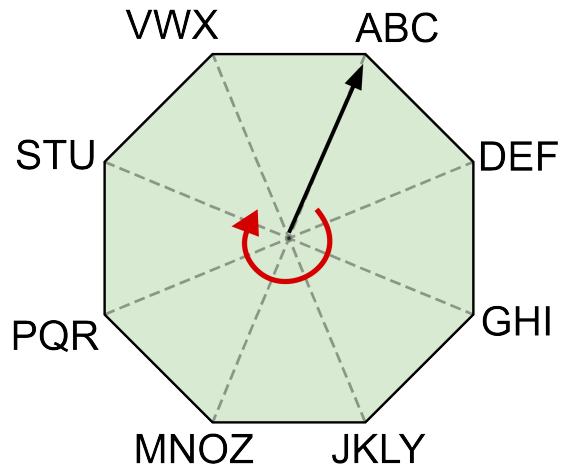
Question

Which item does the robot pick up last?

(A)   (B)   (C)   (D)
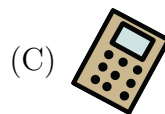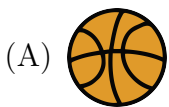
Octagon Cipher

In an octagon cipher, groups of letters are placed at each vertex of an octagon. An arrow points from the center of the octagon to a letter group, and the arrow can rotate clockwise.

This octagon cipher is used to create secret versions of words. For each word, the arrow begins pointing to ABC. Then a pair of digits is generated for each letter in the word as follows:

- The first digit is the number of vertices the arrow should be rotated from its current position to reach the desired letter group (0, 1, 2, 3, 4, 5, 6, or 7).

- The second digit is the position of the desired letter in the letter group (1, 2, 3, or 4).

The pairs of digits are then separated by dashes. For example, the secret version of the word TREE is 62-73-42-02.
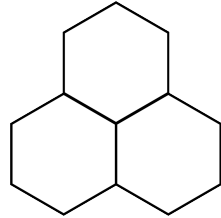
Question

What is the secret version of the word WATER?

(A) 72-11-26-32-53

(B) 62-11-62-22-43

(C) 62-11-26-22-53

(D) 72-11-62-32-43

Colourful Tower

Luis has hexagon pieces in three different colours. Whenever Luis arranges three pieces in a way that resembles an upright triangle, the three pieces must either be *all the same colour*, or *all different colours*. These rules do not apply to other three-piece arrangements. In particular:
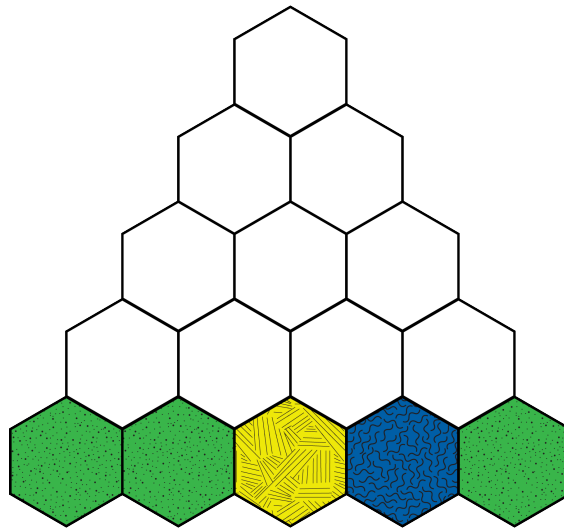
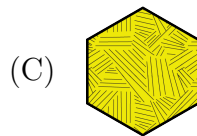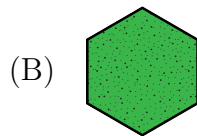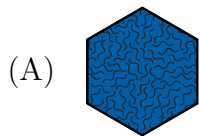All colours the same
or all colours different
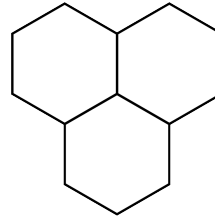
No colour rules

Luis arranges his hexagon pieces in a way that resembles a tower as shown:

Which hexagon piece must be at the very top?

(A)   (B)   (C)   (D) There is more than one possibility

Jumping Game

Verunka has invented a game to play on her sidewalk. Her sidewalk is 13 squares long and there is a coin on the very last square.
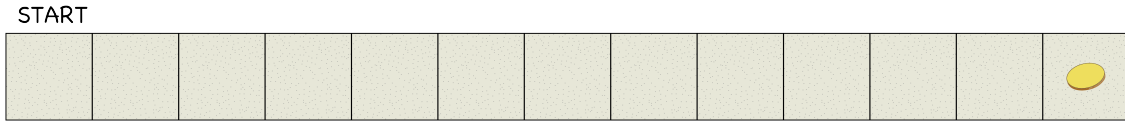
START

Verunka marks each square (except the last) with either an ✖ or an ⭘ . Then, she begins playing by jumping on the square labelled START and using the following rules:

- After landing on a square marked ✖ , jump forward 3 squares.
- After landing on a square marked ⭘ , jump backwards 1 square.

Verunka wins if three things happen:

1. She can always follow the rules (i.e. remain on the sidewalk).
2. She lands on the square with the coin.
3. She visits all 13 squares on the sidewalk.

Question

For which marking will Verunka win the game?

(A) START

(B) START

(C) START

(D) START

7

Part B

Neighbours

Story

A beaver wants to visit his friend Mary. He doesn't know which home is hers, but he has the following map of her neighbourhood, which shows homes numbered from 1 to 8, and paths between some of the homes.
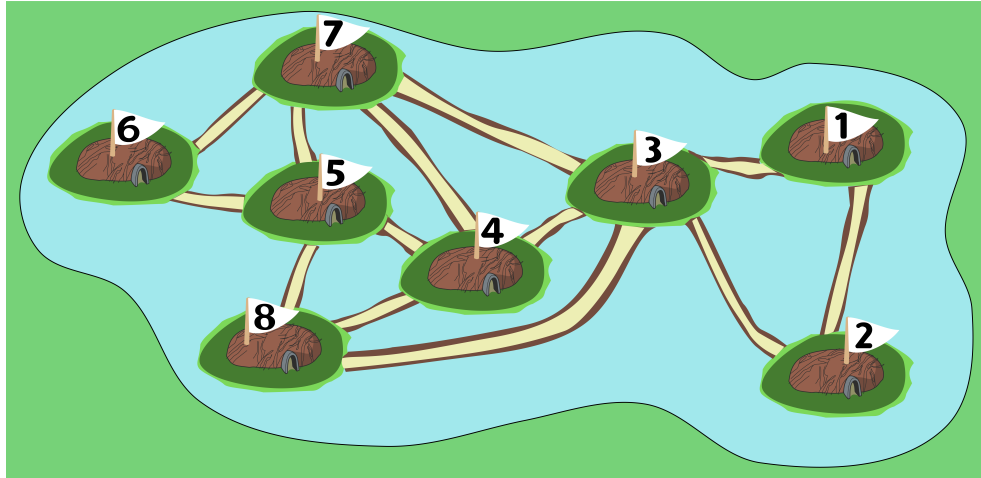
Two beavers are considered neighbours if there is a path that connects their homes directly.

The beaver knows the following information.

- Mary, Zac, and Pan each have exactly four neighbours.

- Niki has exactly two neighbours: Zac and Pan.

Question

What is Mary's house number?

(A) 5

(B) 7

(C) 4

(D) 3

Nuts and Bolts

Story

At the Beaver Construction Factory, Lana works on the nuts ⬡ and bolts 🔩 assembly line.

Her job description is as follows:

- Lana stands at one end of a long conveyor belt, which contains a line of nuts and bolts.
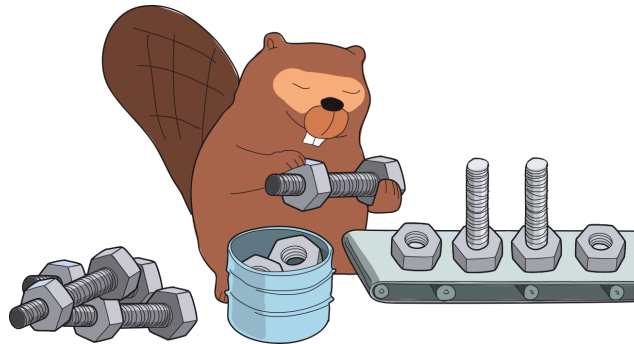
- Lana's job is to take each part, either a nut or a bolt, off of the conveyor belt.

- If Lana takes a nut from the conveyor belt, she puts it in the bucket beside her.

- If Lana takes a bolt from the conveyor belt, she takes a nut from the bucket beside her, attaches the nut and bolt together, and adds this to a pile of assembled parts.

However, things can go wrong for Lana in two different ways:

1. Lana takes a bolt from the conveyor belt, and there is no nut in the bucket to attach it to.

2. There are no more bolts on the conveyor belt, and there are still nuts in the bucket.

Question

Which sequence of nuts and bolts, when processed from left-to-right, will **not** cause things to go wrong for Lana?

(A)

(B)

(C)

(D)
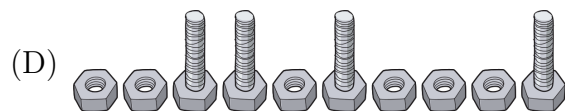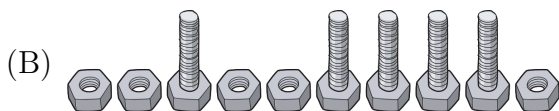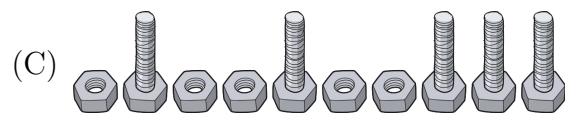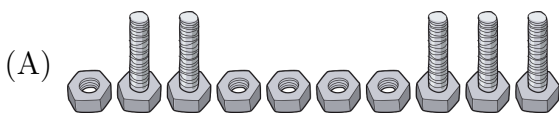
Rug Weaving

Story

Hale is a Turkish weaving artist. He is creating a square rug that consists of a grid of 25 squares arranged into 5 rows and 5 columns. On each square, Hale will place one of the following four symbols:

He decides which symbol to place on each square using the row number and column number of the square and following the instructions in the decision tree given below.

Does the row number and/or the column number equal 1 or 5?
- YES →
- NO → **Does the row number equal the column number?**
  - YES →
  - NO → **Is the row number larger than the column number?**
    - YES →
    - NO →
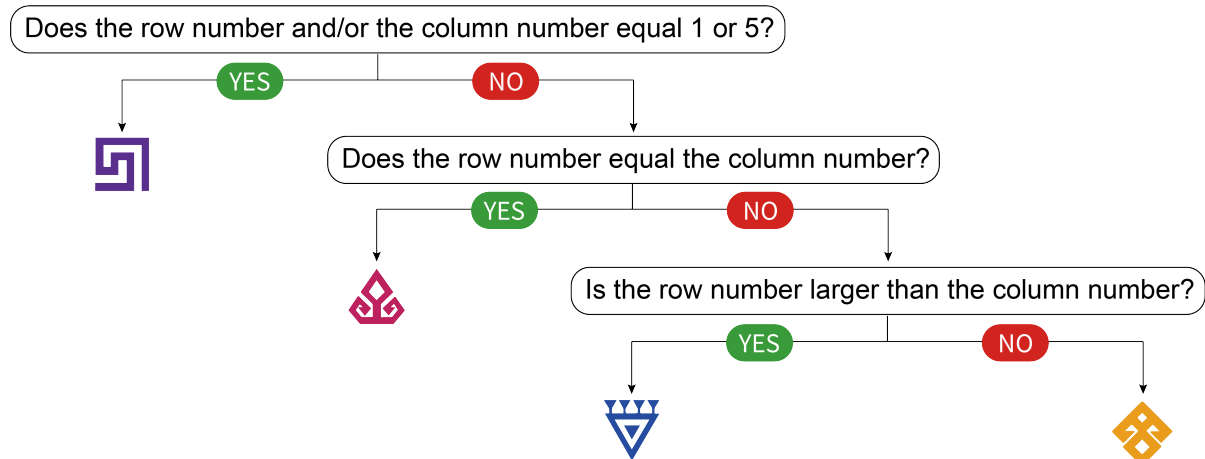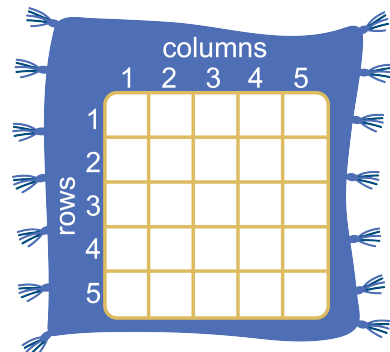
Question

Which of the following rugs is Hale's completed rug?

(A) (B) (C) (D)

11
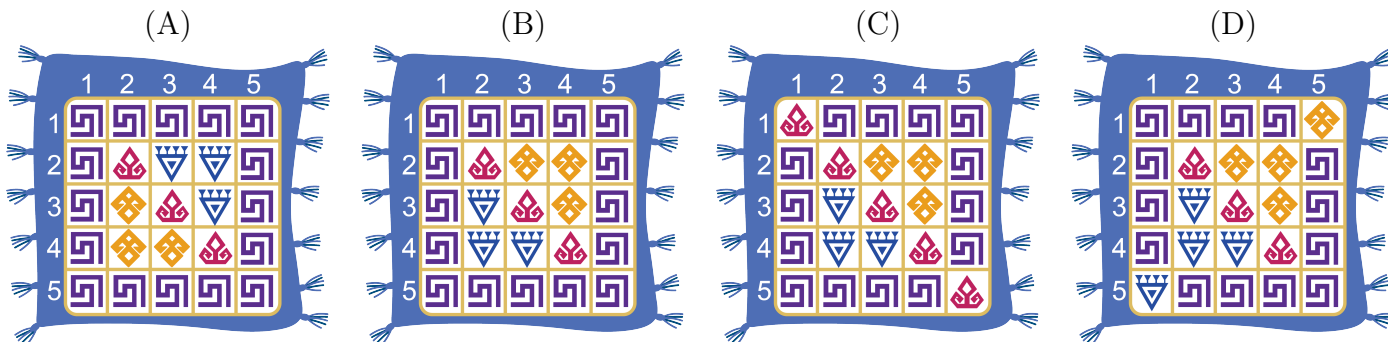
Forest Photos

Story
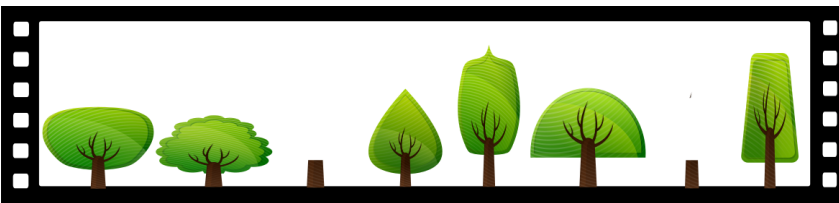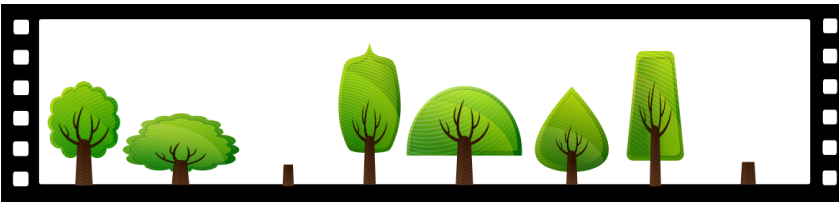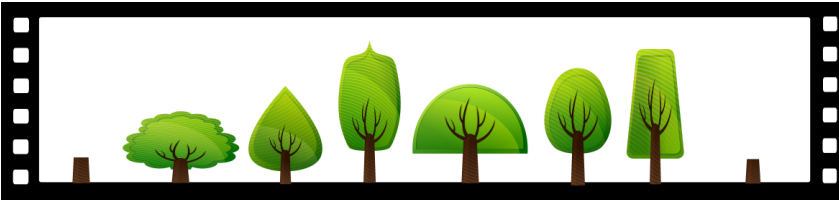
Dai has a camera with a *panorama mode*, which can take one continuous photo while it moves horizontally. Dai stood in the middle of a circle of eight trees, and took the following photo in panorama mode while rotating 360 degrees.
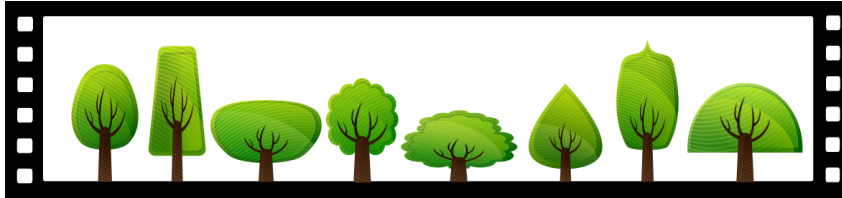
After a few days, Dai returned to the same location and took a second photo moving in the same direction, but starting from a different tree. She saw that two of the trees had been cut down.

Question

Which of the following is Dai's second photo?

(A)

(B)

(C)

(D)

Tiger Dolls

Story

At a carnival, five tiger dolls are initially on a shelf in the order shown below. Bo wants to reorder the dolls so that their heights increase from left to right. Bo rearranges the dolls by switching the positions of two dolls at a time.

Question

What is the fewest number of switches Bo can make in order to place the dolls in the desired order?

(A) 3

(B) 4

(C) 5

(D) 6

Part C

Classroom Seating

Story

There are 31 empty chairs in a classroom. The chairs are placed in a circle and numbered 1 to 31, as shown. Students enter the classroom, one at a time, and fill the chairs in the following way:

1. When a student enters the classroom, they sit on the chair that has the number of the day of the month on which they were born, unless that chair is already occupied.

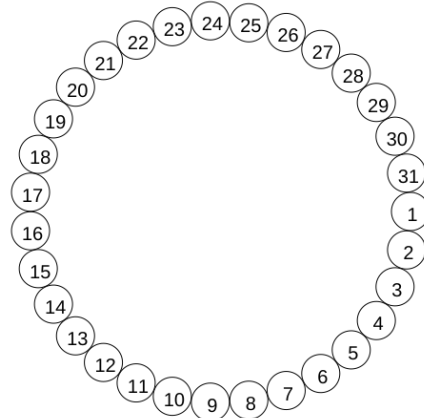2. If that chair is already occupied, then the student starts at that chair and walks around the circle in a clockwise direction, sitting on the first free chair they encounter.

For example, suppose that Geeta and Seeta were both born on April 20, Arun was born on January 21 and Zubin was born on September 22.

- If they enter the classroom in the order Geeta, Seeta, Zubin, Arun, then Geeta sits on chair 20, Seeta sits on chair 21, Zubin sits on chair 22, and Arun sits on chair 23.

- If they instead enter the classroom in the order Seeta, Arun, Zubin, Geeta, then Seeta sits on chair 20, Arun sits on chair 21, Zubin sits on chair 22, and Geeta sits on chair 23.

Question

Suppose six students enter the classroom and are seated as shown:

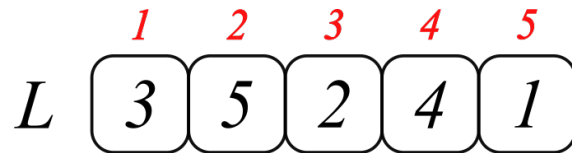| Student	Birthday	Chair Number
Abha	May 11	13
Byram	February 12	12
Chetan	September 14	14
David	August 11	11
Eesha	April 13	15
Fatima	July 12	16

Which of the following statements **cannot** be true?

(A) Chetan was the first student to enter.

(B) Fatima was the sixth student to enter.

(C) Eesha entered before Abha.
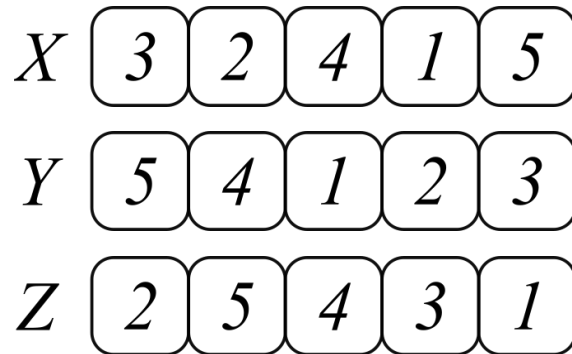
(D) Byram entered before David.

Lists

Story

We can represent a sequence of numbers using a list of boxes. Each number in the sequence is placed in a box and the position of each number in the sequence is indicated above the box. For example, the following list is labelled L and represents the sequence 3, 5, 2, 4, 1.

$$\begin{array}{ccccc} \textit{1} & \textit{2} & \textit{3} & \textit{4} & \textit{5} \end{array}$$

$$L \; \boxed{3}\;\boxed{5}\;\boxed{2}\;\boxed{4}\;\boxed{1}$$

We can use the notation $(L\ N)$ to represent the number that is in position N in list L. For example, $(L\ 2)$ represents the number in position 2 in list L and so $(L\ 2) = 5$. Similarly, $(L\ 5) = 1$.

Note that we can use this notation more than once in an expression. For example, consider the expression $(L\ (L\ 3))$. Since $(L\ 3) = 2$, substituting this value gives $(L\ (\boldsymbol{L}\ \boldsymbol{3})) = (L\ \boldsymbol{2}) = 5$.

Consider the following three lists that are labelled X, Y and Z.

$$X \; \boxed{3}\;\boxed{2}\;\boxed{4}\;\boxed{1}\;\boxed{5}$$

$$Y \; \boxed{5}\;\boxed{4}\;\boxed{1}\;\boxed{2}\;\boxed{3}$$

$$Z \; \boxed{2}\;\boxed{5}\;\boxed{4}\;\boxed{3}\;\boxed{1}$$

Question

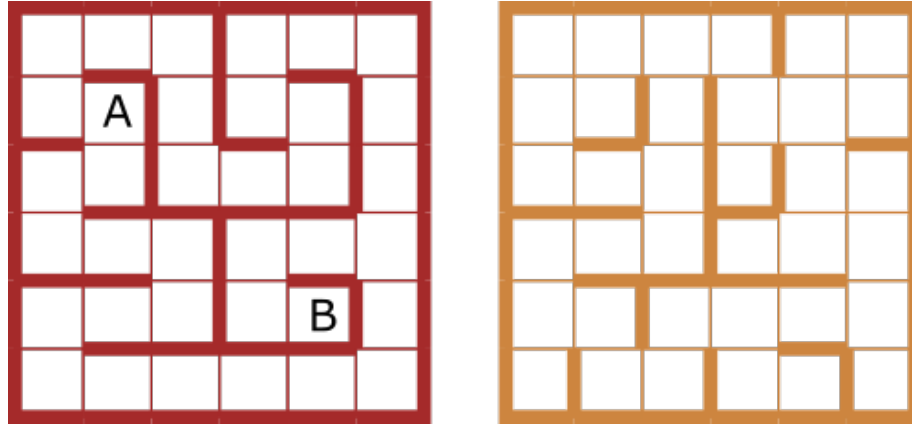What is the number represented by the expression $(X\ (Y\ (Z\ 3)))$?

(A) 2

(B) 3

(C) 4

(D) 5

Maze

A beaver is in a maze that consists of two 6-by-6 floors as shown. The bold lines are walls.

The beaver can move between two adjacent cells within one floor if there is no wall between the cells; this takes one second. The beaver can also magically move to the corresponding cell (same row and same column) of the other floor; this takes five seconds.

For example, if the beaver is in cell A, there are three possible moves:

1. Move left. This move takes 1 second.

2. Move down. This move takes 1 second.

3. Move to the corresponding cell of the other floor. This move takes 5 seconds.

The beaver starts at cell A and wants to reach cell B as soon as possible.

Question

What is the shortest time needed for the beaver to reach cell B?

(A) 17 seconds

(B) 18 seconds

(C) 19 seconds

(D) 20 seconds

Variety Pack

Story

A company sells four different bottled drinks. The bottles are all identical in shape and size, but different drinks have different coloured labels. The red drink is always packaged in a 3 by 5 crate holding 15 bottles, the blue drink in a 3 by 4 crate holding 12 bottles, the green drink in a 2 by 3 crate holding 6 bottles, and the yellow drink in a 1 by 5 crate holding 5 bottles.
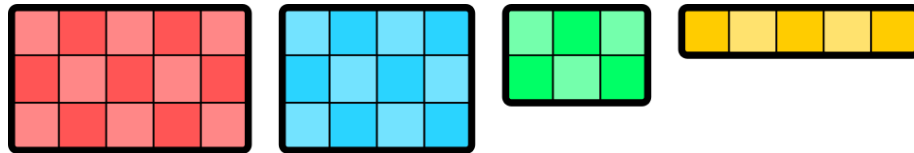
The company wants to sell a "Variety Pack" that includes exactly one crate of each of the four drinks. The Variety Pack is to be packaged in a rectangular container with all four drink crates placed flat on the base of the container. The following diagram shows how a Variety Pack can be made using a rectangular container that is 5 bottles wide and 9 bottles long.
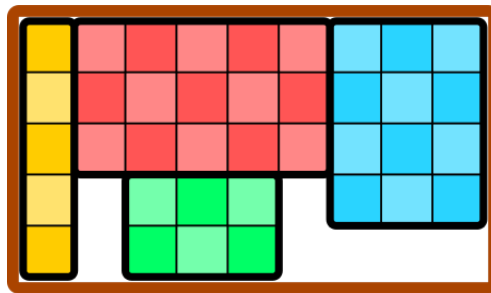
Notice that 7 additional bottles would need to be placed in this container in order to fill the area of the base.

Question

Suppose that a rectangular container is chosen for the Variety Pack so that the four drink crates can be packaged with the least possible amount of empty space on the base of the container. In this case, how many additional bottles would need to be placed in the container in order to fill the area of the base?

(A) 1

(B) 2

(C) 4

(D) 6

Story

Birgit is creating numbers using the following diagram:
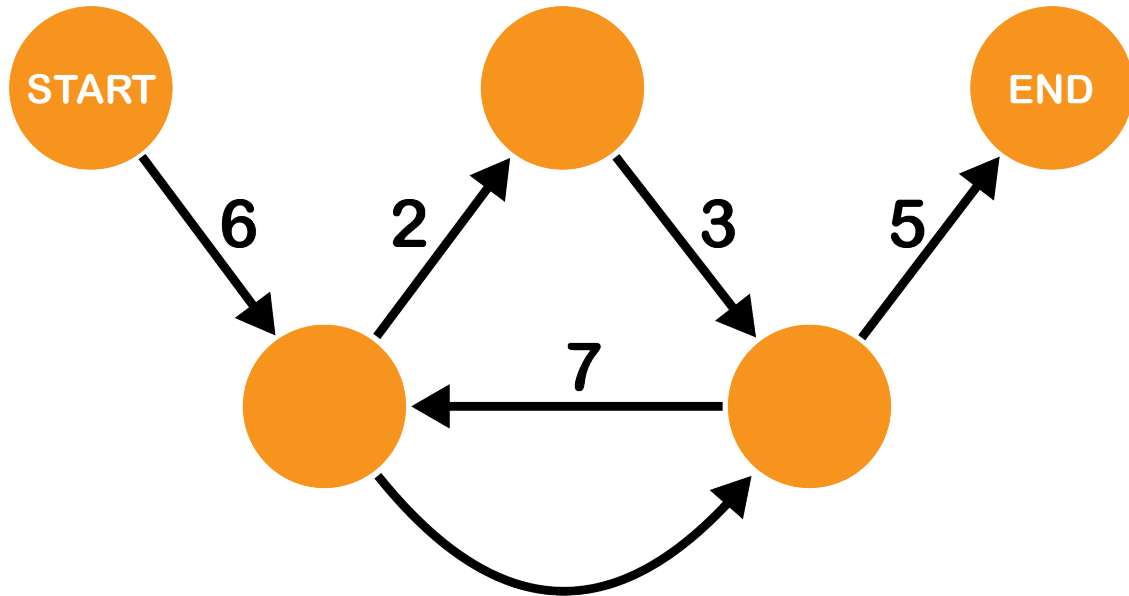
To create a number they start in the circle labelled START and then they follow arrows until they reach the circle labelled END.

If the arrow they follow is labelled with a digit, they write down that digit as part of their number. One arrow is unlabelled which means Birgit can follow it without writing down any digit.

For example, Birgit can create the number 6235 and the number 67775, among others.

Question

How many different 8-digit numbers can Birgit create?

(A) 5

(B) 9

(C) 12

(D) 14