

# CTA-M

## Computational Thinking Abilities-Middle Grades Assessment

Validation paper for the combined CTt and Bebras items:

Wiebe, E., London, J., Aksit, O., Mott, B. W., Boyer, K. E., & Lester, J. C. (2019, February). Development of a Lean Computational Thinking Abilities Assessment for Middle Grades Students. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education* (pp. 456-461). ACM.

The CTA-M consists of items originally contained in the *CTt* and *Bebras UK 2016* instruments.

CTt was developed by M. Román-González and colleagues. CTt items below are redistributed with the permission of M. Román-González.

Appropriate development and validation citations include:

Román-González, M., Pérez-González, J.-C., & Jiménez-Fernández, C. (2016). Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test. *Computers in Human Behavior*, 72, 678-691. doi: <http://dx.doi.org/10.1016/j.chb.2016.08.047>

Román-González, M., Pérez-González, J.-C., Moreno-León, J., & Robles, G. (2018). Can computational talent be detected? Predictive validity of the Computational Thinking Test. *International Journal of Child-Computer Interaction*, 18, 47-58.

The Bebras UK 2016 items were developed by the Working Group for UK Bebras Computational Challenge and released through the following document:

Blokhuis, D., Millican, P., Roffey, C., Schrijvers, E., & Sentance, S. (2016). *UK Bebras Computational Thinking Challenge 2016*. Oxford, UK: University of Oxford. Accessed March, 2017 at <http://www.bebas.uk/>

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Notes:

1. Two items, RG\_Q23 and B\_Q7, have been found to have less than optimal psychometric properties in subsequent analysis since the above paper was published. We are now recommending a 23-item instrument with these two items excluded.
2. Item codes for the items as used in our published research are on the left side
3. Correct answers to questions are also on the left (e.g., Key = 2 means the second option is the correct one)

# CTt items

Item Number

Item

RG\_3

Key = 4

## Question 3

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

*The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a **mistake**?*

The grid shows a 10x8 area. Pac-Man is at row 4, column 3. A ghost is at row 2, column 5. A yellow path is marked: (4,3) to (4,4), (4,5), (4,6), (3,6), (2,6), (2,5).

move forward → Step A  
turn left ↺ → Step B  
move forward → Step C  
move forward → Step D  
turn left ↺  
move forward

## Question 3

Select the step in which there is a mistake

- A
- B
- C
- D


RG\_Q7

Key = 1

### Question 7

The instructions should make the artist draw the following rectangle once (50 pixels wide and 100 pixels high). In which step of the instructions is there a mistake?

*The instructions should make the artist draw the following rectangle **once** (50 pixels wide and 100 pixels high). In which step of the instructions is there a **mistake**?*



```
repeat 4 times
do
  move forward by 50 pixels
  turn left by 90 degrees
  move forward by 100 pixels
  turn left by 90 degrees
```

Step A points to the repeat block.

Step B points to the first turn left block.

Step C points to the second move forward block.

Step D points to the second turn left block.

### Question 7

Select the step in which there is a mistake

- A
- B
- C
- D

RG\_Q11

Key = 3

### Question 11

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

*The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a **mistake**?*

The diagram illustrates a sequence of four steps (Step A, Step B, Step C, Step D) indicated by red arrows pointing upwards. A box labeled "Repeat until the..." with a ghost icon contains a right arrow followed by a box with "x 2" and an up arrow.

### Question 11

Select the step in which there is a mistake


- A
- B
- C
- D

RG\_Q12

Key = 1

### Question 12

Which instructions should the artist follow to draw the ladder that reaches the flower? There are 30 pixels between each rung.

<p>Which instructions should the artist follow to draw the ladder that reaches the flower? There are 30 pixels between each rung.</p> 	<p>Option A</p> <pre>Repeat until the flower do   repeat 4 times   do     move forward by 30 pixels     turn right by 90 degrees   jump forward by 30 pixels</pre>	<p>Option B</p> <pre>Repeat until the flower do   repeat 4 times   do     move forward by 120 pixels     turn right by 90 degrees   jump forward by 30 pixels</pre>
	<p>Option C</p> <pre>Repeat until the flower do   repeat 4 times   do     move forward by 30 pixels     turn right by 90 degrees   jump forward by 210 pixels</pre>	<p>Option D</p> <pre>Repeat until the flower do   repeat 7 times   do     move forward by 30 pixels     turn right by 90 degrees   jump forward by 30 pixels</pre>

### Question 12

Select the correct answer

- A
- B
- C
- D

### Question 13

Which instructions take 'Pac-Man' to the ghost by the path marked out?

Which instructions take 'Pac-Man' to the ghost by the path marked out?

<p>Option A</p>	<p>Option B</p>
<p>Option C</p>	<p>Option D</p>

### Question 13

Select the correct answer

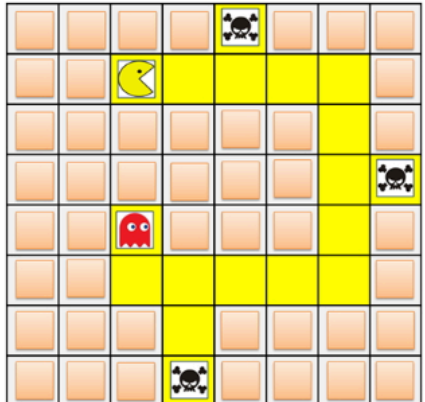
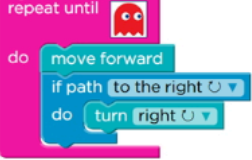

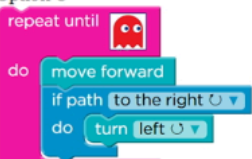
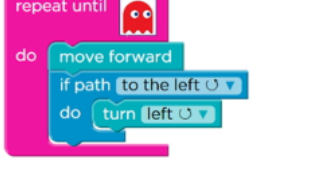
- A
- B
- C
- D

RG\_Q14

Key = 1

### Question 14

Which instructions take 'Pac-Man' to the ghost by the path marked out?

<p>Which instructions take 'Pac-Man' to the ghost by the path marked out?</p> 	<p>Option A</p> 	<p>Option B</p> 
	<p>Option C</p> 	<p>Option D</p> 

### Question 14

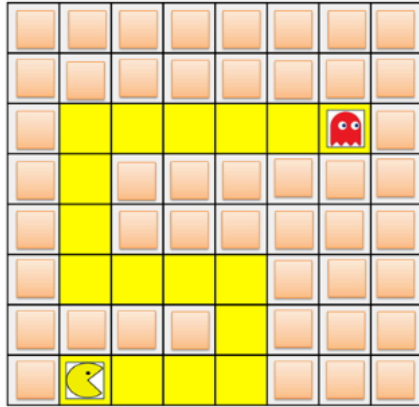
Select the correct answer

- A
- B
- C
- D

### Question 16

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a **mistake**?



```
repeat until [ghost icon]
do
  move forward
  if path [to the left]
  do
    turn left
  if path [to the right]
  do
    move forward
```

Step A points to the 'to the left' block.

Step B points to the 'turn left' block.

Step C points to the 'to the right' block.

Step D points to the 'move forward' block at the end of the loop.

### Question 16

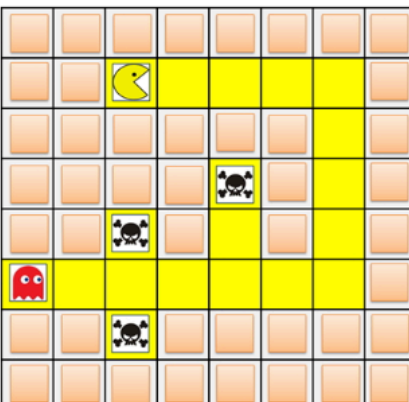

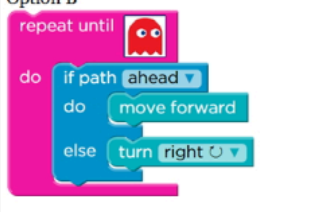


Select the step in which there is a mistake

- A
- B
- C
- D



### Question 17

Which instructions take 'Pac-Man' to the ghost by the path marked out?

<p>Which instructions take 'Pac-Man' to the ghost by the path marked out?</p> 	<p>Option A</p> 	<p>Option B</p> 
	<p>Option C</p> 	<p>Option D</p> 

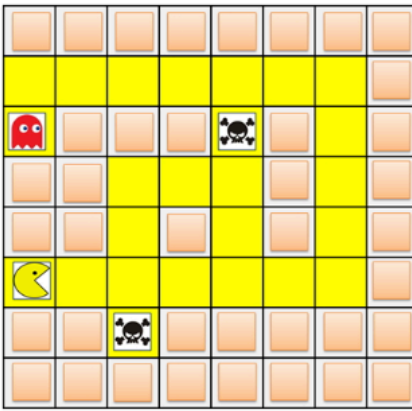

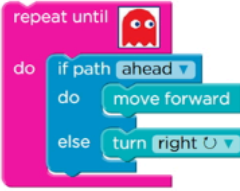
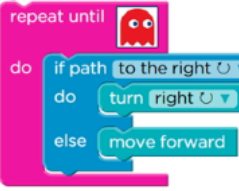
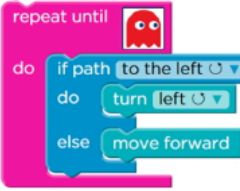
### Question 17

Select the correct answer

- A
- B
- C
- D

### Question 18

Which instructions take 'Pac-Man' to the ghost by the path marked out?

<p>Which instructions take 'Pac-Man' to the ghost by the path marked out?</p> 	<p>Option A</p> 	<p>Option B</p> 
	<p>Option C</p> 	<p>Option D</p> 

### Question 18

Select the correct answer

- A
- B
- C
- D

### Question 19

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

*The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a **mistake**?*

```
repeat until 
do
  if path ahead
  do move forward → Step A
  else
  if path to the right
  do turn left → Step C
  else
  do turn right → Step D
  → Step B
```

### Question 19

Select the step in which there is a mistake

- A
- B
- C
- D

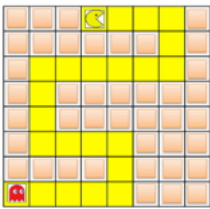

RG\_Q20




Key = 3

### Question 20

Which step is missing in the instructions below to take 'Pac-Man' to the ghost by the path marked out?

Which step is missing in the instructions below to take 'Pac-Man' to the ghost by the path marked out?



Option A 	Option B 
Option C 	Option D <i>Not missing any step</i>

### Question 20

Select the correct answer

- A
- B
- C
- D

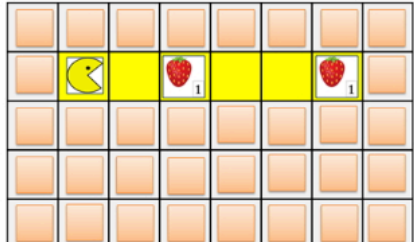
RG\_Q23

\*Removed for the 23-item instrument

Key = 1

### Question 23

What is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?

<p>What is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?</p> <pre>while path ahead do   repeat ????????????? do   move forward if any strawberries do   Eat 1 strawberry</pre> 	<p>Option A <i>1 time</i></p> <p>Option B <i>2 times</i></p> <p>Option C <i>3 times</i></p> <p>Option D <i>5 times</i></p>
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### Question 23

Select the correct answer


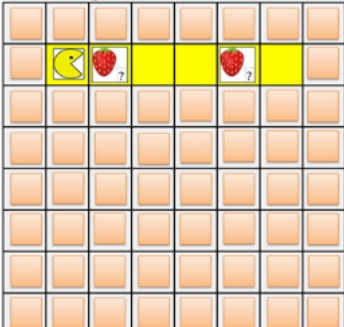
- A
- B
- C
- D

RG\_Q24

Key = 3

### Question 24

Which step is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries (unknown number)?

<p>Which step is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries (unknown number)?</p>  	<p>Option A</p> <p><b>While path ahead</b></p> <hr/> <p>Option B</p> <p><b>While no path ahead</b></p> <hr/> <p>Option C</p> <p><b>While any strawberries</b></p> <hr/> <p>Option D</p> <p><b>While no strawberries</b></p>
--	---

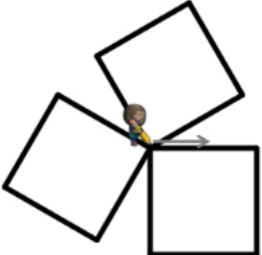
### Question 24

Select the correct answer

- A
- B
- C
- D

### Question 25

Which instructions should the artist follow to draw the following design? Each side of each square measures 100 pixels.

<p>The following set of instructions is called <b>'my function'</b>, and draws one square of 100 pixels each side:</p> <pre> Function my function repeat 4 times do   move forward by 100 pixels   turn right by 90 degrees         </pre>	<p>Option A</p> <pre> repeat 3 times do   my function turn right by 120 degrees         </pre>	<p>Option B</p> <pre> repeat 3 times do   my function   turn right by 120 degrees         </pre>
<p>Which instructions should the artist follow to draw the following design? Each side of each square measures 100 pixels.</p> 	<p>Option C</p> <pre> repeat 4 times do   my function turn right by 90 degrees         </pre>	<p>Option D</p> <pre> repeat 4 times do   my function   turn right by 90 degrees         </pre>

### Question 25

Select the correct answer

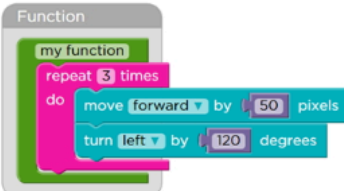
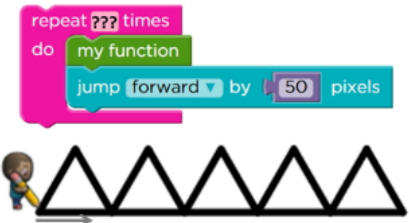
- A
- B
- C
- D

RG\_Q26

Key = 2

### Question 26

The instructions below should make the artist draw the following design. Each side of each triangle measures 50 pixels. What is missing in the instructions?

<p>The following set of instructions is called 'my function', and draws one triangle of 50 pixels each side:</p> 	<p>Option A</p> <p>15</p>	<p>Option B</p> <p>5</p>
<p>The instructions below should make the artist draw the following design. Each side of each triangle measures 50 pixels. What is missing in the instructions?</p> 	<p>Option C</p> <p>4</p>	<p>Option D</p> <p>3</p>

### Question 26

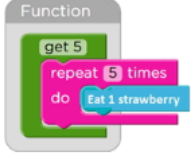
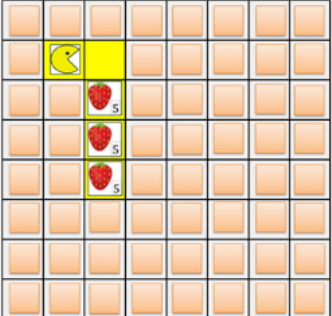




Select the correct answer

- A
- B
- C
- D



### Question 27

Which instructions take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?

<p>The following set of instructions is called 'get 5':</p>  <p>Which instructions take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?</p> 	<p>Option A</p> 	<p>Option B</p> 
	<p>Option C</p> 	<p>Option D</p> 

### Question 27

Select the correct answer

- A
- B
- C
- D

## Bebras items

B\_Q1

Key = 1

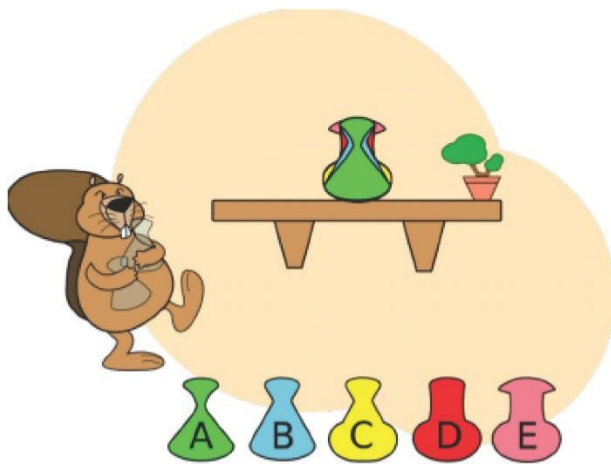
### Question 1

A Beaver puts five bottles on a table.

He places them so that every bottle has a bit showing.

He places the first bottle at the back of the table and puts each new bottle in front of those already placed.

What could be the right order of bottles from first to last?



### Question 1

Select the correct answer

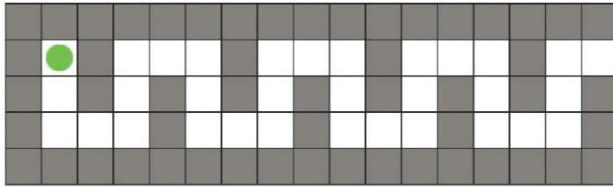
- EDCBA
- DBCAE
- ECDAB
- DCEBA

B\_Q6

Key = 3

### Question 2

Help the green robot to exit the maze.



The arrows below represent the instructions that the green robot can follow.



Choose the correct set of instructions that will take the green robot to the exit. The robot will repeat these instructions 4 times.

### Question 2

Select the correct answer

- 4x
- 4x
- 4x
- 4x

B\_Q7  
\*Removed  
for the 23-  
item  
instrument

Key = 1

### Question 3

Beaver Bert has a long strip of colored paper for a party. The strip has three different colors (yellow, red, blue) in a regularly repeating pattern. Bert's friend, James, has cut out a section of the paper, as shown in the diagram below.



James says that he will give back the missing piece of paper if Bert can correctly guess the size of the piece cut out.

Question:

How many colored squares does the missing piece of paper have?

### Question 3

Select the correct answer

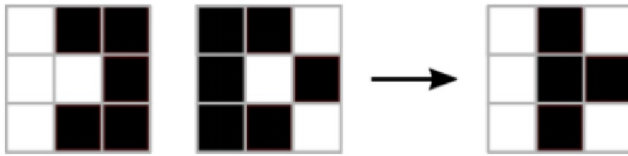
- 31
- 32
- 33
- 34

B\_Q8

Key = 1

### Question 4

Combining Card A and Card B, you get Card C:



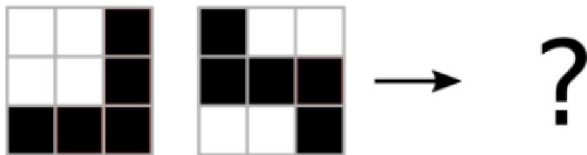
Card A

Card B

Card C

Question:

How many black cells will Card F have after combining Card D and Card E?



### Question 4

Select the correct answer

- 3
- 4
- 5
- 6

B\_Q9

Key = 3

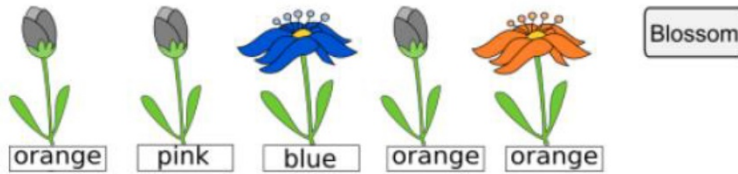
### Question 5

Jane is playing a computer game.

First, the computer secretly chooses colors for five buds. The available colors for each flower are blue, orange, and pink. Jane has to guess which flower has which color. She makes her first five guesses and presses the Blossom button.

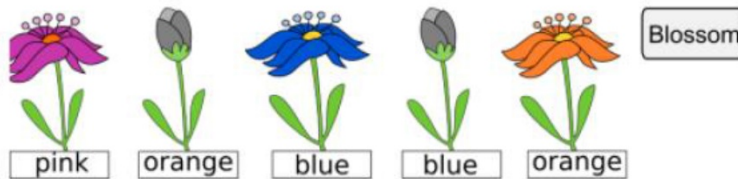
The buds, whose colors she guessed correctly, break into flowers. The others remain as buds.

Jane's first go:



Jane then has another go at guessing and presses the Blossom button again.

Jane's second go:



Question:

What colors did the computer choose for the flowers?

### Question 5

Select the correct answer

- blue pink blue orange orange
- pink blue blue blue orange
- pink blue blue pink orange
- pink pink blue pink orange

B\_Q10

Key = 4

## Question 6

Betaro Beaver has discovered five new magic potions:

- one makes ears longer
- another makes teeth longer
- another makes whiskers curly
- another turns the nose white
- the last one turns eyes white.

Betaro put each magic potion into a separate beaker. He put pure water into another beaker, so there are six beakers in total. The beakers are labeled A to F. The problem is, he forgot to record which beaker contains which magic potion!

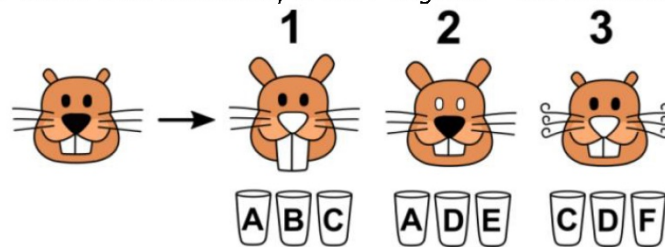


To find out which potion is in each beaker, Betaro set up the following experiments:

Expt 1: A beaver drinks from beakers A, B and C together - the effects are shown in Figure 1.

Expt 2: A beaver drinks from beakers A, D and E together - the effects are shown in Figure 2 .

Expt 3: A beaver drinks from beakers C, D and F together - the effects are shown in Figure 3.



Question:

Which beaker contains pure water?

## Question 6

Select the correct answer

- A
- B
- C
- D
- E
- F

B\_Q13

Key = 2

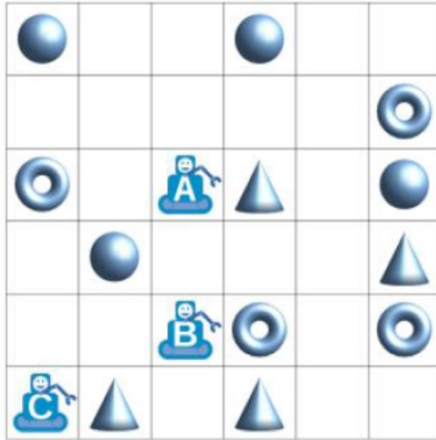
### Question 7

In a warehouse, three robots always work as a team.

When the team gets a direction instruction (N, S, E, W), all robots in the grid will move one square in that direction at the same time.

After following a list of instructions, the robots all pick up the object found in their final square.

For example, if we give the list N, N, S, S, E to the team, then robot A will pick up a cone, robot B will pick up a ring, and robot C will pick up a cone.



Question:

Which list of instructions can be sent to the robots so that the team picks up exactly a sphere, a cone, and a ring?

### Question 7

Select the correct answer

- N, E, E, E
- N, E, E, S, E
- N, N, S, E, N
- N, E, E, S, W



B\_Q14

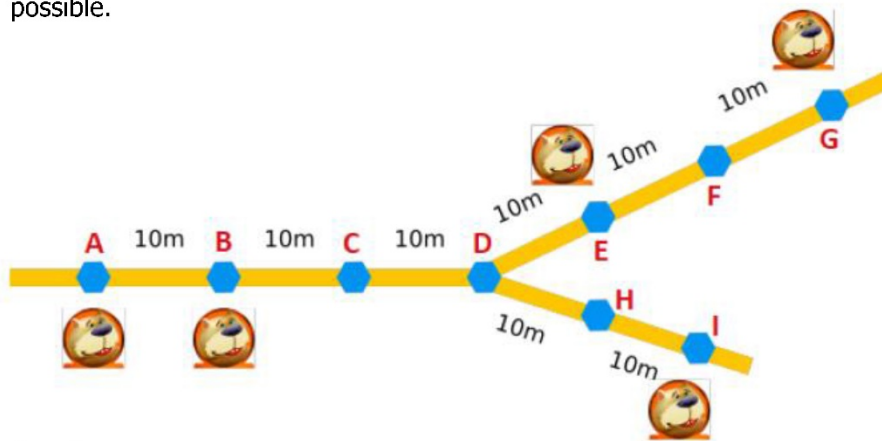
Key = 4

### Question 8

The lodges of five beavers are shown on the map below.

The Beavers want to put a bus stop in one of the places marked by blue hexagons. All the hexagons are 10m apart.

The beavers decide that the sum of the distances from their lodges to the bus stop must be as small as possible.



Question:

Which is the best place for the bus stop?

### Question 8

Select the correct answer

- A
- B
- C
- D
- E
- F
- G
- H
- I

B\_Q15

Key = 2

### Question 9

Agents Boris and Bertha communicate using secret messages.  
Boris wants to send Bertha the secret message:

MEETBILLYBEAVERAT6

He writes each character in a 4 column grid from left to right and row by row starting from the top. He puts an X in any unused spaces. The result is shown below.



Then he creates the secret message by reading the characters from top to bottom and column by column starting from the left:

MBYVTEIBE6ELERXTLAAX

Bertha then uses the same method to reply to Boris. The secret message she sends him is:

OIERKLTEILH!WBEX

Question:

What message does Bertha send back?

### Question 9

Select the correct answer

- OKWHERE TOMEET!
- OKIWILLBETHERE!
- WILLYOUBETHERETOO?
- OKIWILLMEETHIM!