Continental Mathematics League

2014 - 2015

Computer Science Contest

Grades 3-5

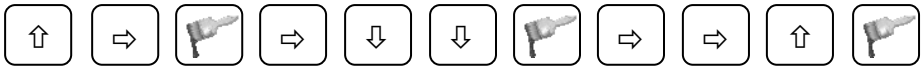
The contest consists of three "meets." Each meet has six questions for 30 minutes.

Note: Some questions have multiple answers. All parts of the question must be answered correctly for a student to receive credit for the problem.

Meet 1

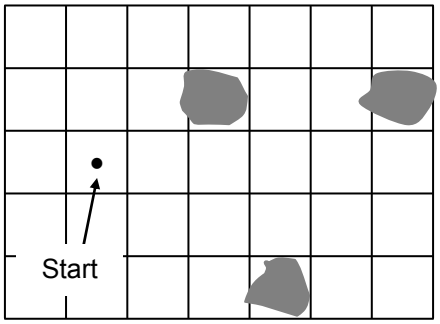
1. Pink Painter is a programmable robot. She can move left, right, up, and down, and paint the square she is on. These five commands are represented by the blocks

Pink Painter was given this program:

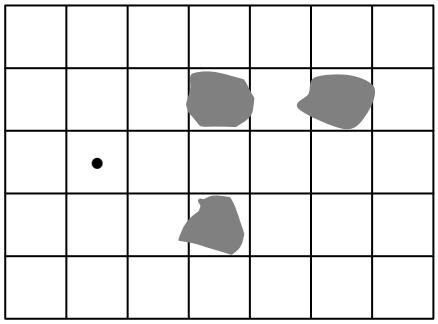


Which picture did Pink Painter paint?

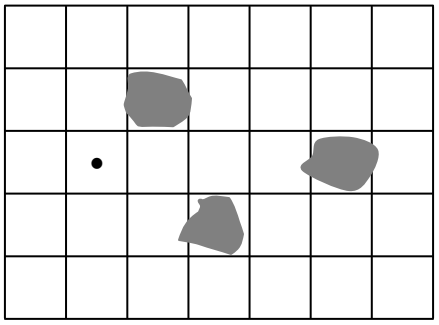
(A)



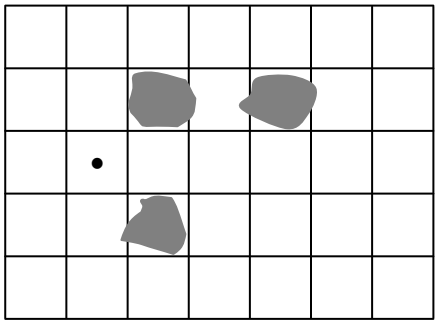
(B)



(C)



(D)



Answer: _____

2. Fill in the blank:

```
0001    1
0010    2
0011    3
0100    4
0101    5
0110    6

.....

1001    _____
```

3. Python is a popular programming language. Here is a very short program in Python:

```
x = int(input("Enter a positive integer: "))
if x > 5:
    print(x - 5)
else:
    print(1)
```

It asks the user to enter a number. If the user enters 4, the program displays 1; if the user enters 7, the program displays 2. What does the program display if the user enters 10?

Answer: _____

4. A *bit* can only be 0 or 1. You can make four different two-bit codes:

```
00  01  10  11
```

With three bits you can make eight different codes:

```
000  001  010  011  100  101  110  111
```

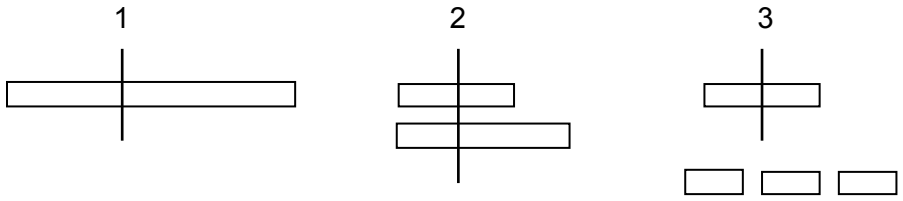
How many different codes can you make with five bits?

Answer: _____

5. Java is a widely used programming language. In Java you can use the plus sign to join together two strings of letters. For example, `"car" + "pool"` makes `"carpool"`. There is also a `substring` command that skips the first several letters and takes the remaining letters. For example, `"carpool".substring(3)` skips the first three letters in `"carpool"` and makes `"pool"`. What does `("good" + "day").substring(2)` make?

   Answer: _____

6. You need to cut a stick of celery into several pieces that are all about the same length. You can cut two or even three pieces together, in one cut. It is possible to cut the celery into five pieces with three cuts. For example:

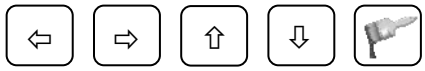


   That's the smallest possible number of cuts. What is the smallest number of cuts needed to cut the stick into seven pieces?

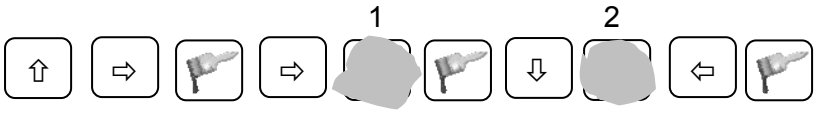
   Answer: _____

Meet 2

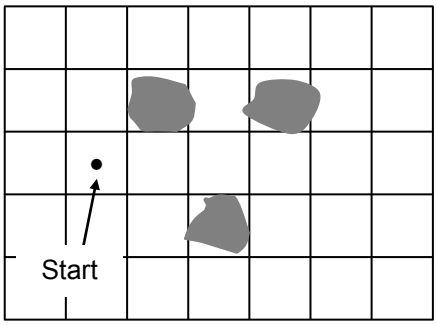
1. Pink Painter is a programmable robot. She can move left, right, up, and down, and paint the square she is on. These five commands are represented by the blocks



Pink Painter was given this program (in which two blocks are hidden):



She painted this:



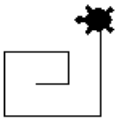
What commands are not shown?

Answer: 1:_____ 2: _____

2. Python is a popular programming language. It has commands for "turtle graphics." This program —

```
sally = Turtle("turtle")
distance = 20  # initial length of the line to draw
while distance <= 60:
    sally.forward(distance)
    sally.left(90)  # turn left 90 degrees
    sally.forward(distance)
    sally.left(90)
    distance = distance + 20 # Add 20 to distance
```

— makes this picture:

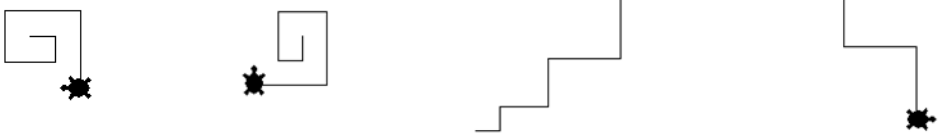


If you change just one word (as shown in bold) —

```
sally = Turtle("turtle")
distance = 20  # initial length of the line to draw
while distance <= 60:
    sally.forward(distance)
    sally.left(90)  # turn left 90 degrees
    sally.forward(distance)
    sally.right(90)
    distance = distance + 20 # Add 20 to distance
```

— what picture will the program make?

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



Answer: _____

3. Month and day are represented by numbers: 1-12 for months, and 1-31 for days. Given `current_year`, `current_month`, `current_day`, and `birth_year`, `birth_month`, `birth_day`, this program piece computes the current age of the person (in years):

```
age = current_year - birth_year
if < missing condition >:
    age = age - 1; // Reduce age by 1
```

What should < *missing condition* > be? Choose the best answer.

(A) `current_month < birth_month or current_day < birth_day`

(B) `current_month < birth_month and current_day < birth_day`

(C) `current_month is birth_month and current_day < birth_day`

(D)
```
current_month < birth_month or
current_month is birth_month and current_day < birth_day
```

Answer: _____

4. Computers frequently perform *bit-wise logical* operations on *bitstrings* (strings of *bits*). A bit is 0 or 1. The AND and OR operations are performed on two bits in the same position in the two bitstrings. AND works like this: If both bits are 1, the result of AND is 1; otherwise it is 0. For example:

```
  10110
AND 01110
  -----
  00110
```

OR works like this: If both bits are 0, the result is 0, otherwise it is 1. For example:

```
  10110
OR  01110
  -----
  11110
```

There is also a NOT operation, which is performed on one bitstring, like this: if the bit is 1 the result of NOT is 0, and if the bit is 0 the result of NOT is 1. For example, NOT of `10110` is `01001`.

What is the result of: NOT (`01011` AND `10111`) OR NOT (`10000` OR `00110`)

Answer: _____

5. Chatty is a chatbot, a program that keeps up an "intelligent conversation" with the user. Suppose Chatty's code has this "if-else" statement:

```
if "dude" in user_input:
    print("hey, yo")
else:
    print("hello")
```

So if `user_input` is `"hi dude"`, Chatty will print `"hey, yo"`, and if `user_input` is `"hello there"`, Chatty will print `"hello"`.

Now suppose Chatty's code has these two "if" statements:

```
if "morning" in user_input:
    print("Good morning")
if "evening" in user_input:
    print("Good evening")
```

If `user_input` is `"it rained in the evening but cleared up by morning"`, what will Chatty print?

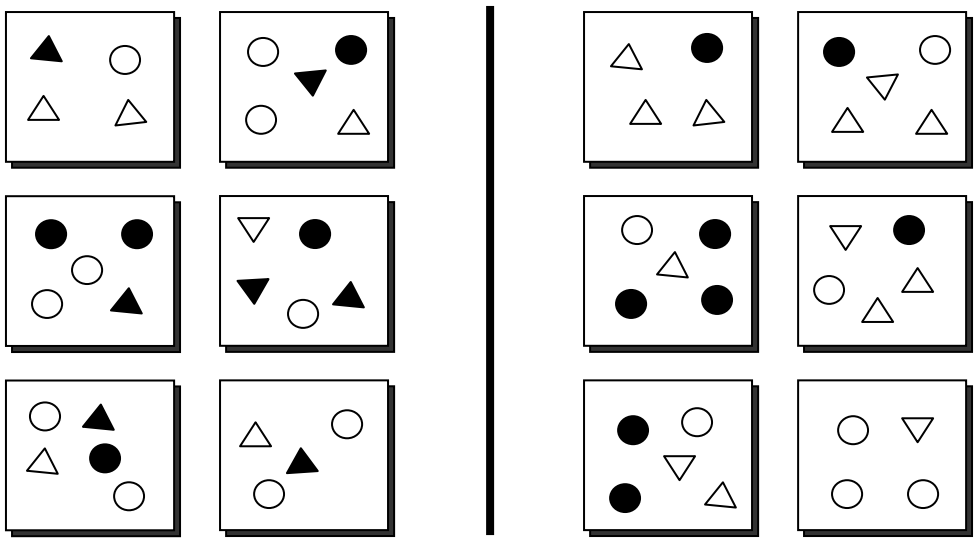
(A)
```
Good morning
```

(B)
```
Good morning
Good evening
```

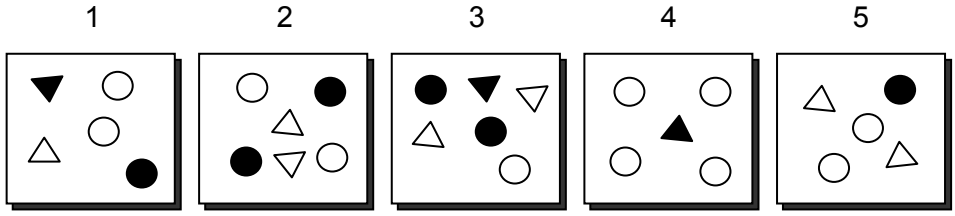
(C)
```
Good evening
```

(D)
```
Good evening
Good morning
```

6. Mikhail Bongard, a Russian computer scientist, invented a kind of puzzle that a computer was supposed to solve. Here is one:



The six pictures to the left of the dividing line are in some way different from the six pictures to the right. Here are five more pictures:



Three of them belong with the left-side pictures. Which ones?

Answer: _____, _____, and _____ .

Meet 3

1. Python is a popular programming language. In Python you can use a plus sign to merge two lists into one. For example, `[3, 2, 1] + [5, 4]` makes `[3, 2, 1, 5, 4]`. You can also use the multiplication sign `*` to duplicate a list a number of times. For example, `3*[1, 2]` makes `[1, 2, 1, 2, 1, 2]`. What does `3*[0] + [1, 2, 3]` make?

   (A) `[3, 0, 1, 2, 3]`
   (B) `["000", 1, 2, 3]`
   (C) `[0, 0, 0, 1, 2, 3]`
   (D) `[0, 1, 2, 3, 0, 1, 2, 3, 0, 1, 2, 3]`

   Answer: _____

2. In the old days, when digital data were transmitted over a telephone line, the data was encoded into 0s and 1s and arranged into *bytes*. A byte is 8 bits. A bit is 0 or 1. The first seven bits were used for data; the last bit, called a *parity* bit, was set to 0 or 1 to make the number of 1s in each byte even or to make the number of 1s in each byte odd. This helped detect transmission errors. Which one of these six bytes was received with an error?

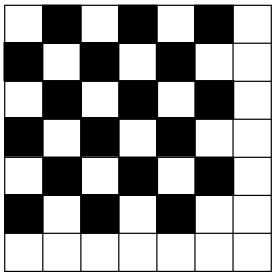
1	2	3	4	5	6
01011010	11010111	00011000	11010110	10000111	11101000

   Answer: _____

3. Pink Painter is a programmable robot. She can move left, right, up, and down, and paint the square she is on. These five commands are represented by the blocks

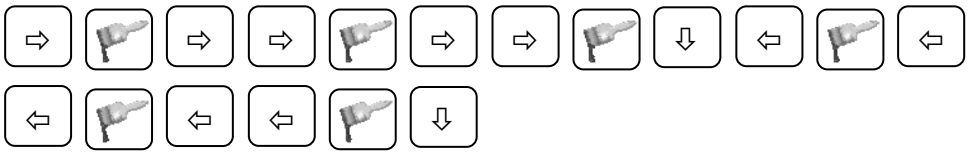
Pink Painter also understands the `repeat` command to repeat the same steps several times.

Aaron and Betty made two different Painter programs to draw a checkerboard pattern, like this (assuming Painter starts in the upper left square):



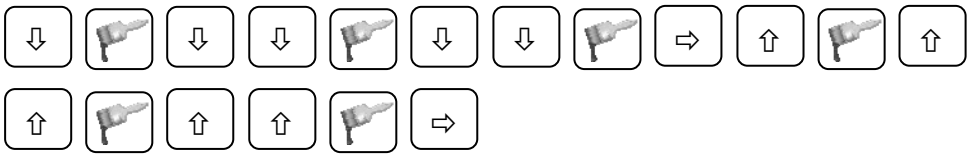
Aaron's program:

```
repeat 3 times:
```



Betty's program:

```
repeat 3 times:
```

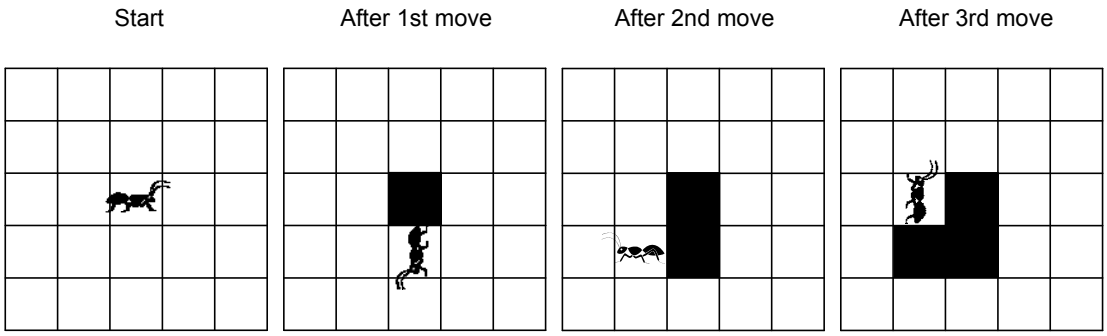


Which of these programs will work?

(A) Both
(B) Only Aaron's
(C) Only Betty's
(D) Neither

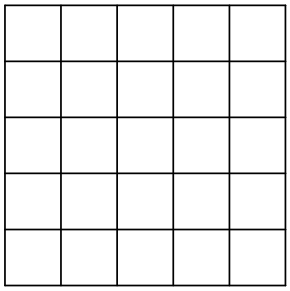
Answer: _____

4. Langton's ant (named after the computer scientist Chris Langton) moves on a grid and acts strangely: if it is on a white square, it turns right; if it is on a black square, it turns left. Either way, it then flips the color of the square from white to black or from black to white and moves forward by one square. This is what the first three moves would look like if the ant was placed on an all-white grid, facing to the right:



What will the board look like if the ant is removed after six moves?

Answer:



5. Computers use the *binary number system* to store numbers. There are only two digits in binary: 0 and 1. The numbers 1, 2, 4, 8, 16, and so on, are called *powers of 2*. Any number is the sum of some of the powers of 2. The digits in a binary number tell you which powers of 2 to include in the sum, and which to skip (1 means "include," 0 means "skip"). For example, if you read 1011 <u>from right to left</u>, it means "take 1, take 2, skip 4, take 8," so it represents 1 + 2 + 8 = 11. Which number is represented by 100110?

Answer: _____

6. Peripatetic (Peri for short) is a robot that walks continuously forward (from the left wall to the right wall), then back, then forward again, then back again, and so on. Ethan created an *algorithm* (a set of instructions) for Peri and wrote it in *pseudocode* (precisely enough, but not as formally as in any programming language). What condition did Ethan use for Pery to make a U-turn?

(A)
```
if (walkingForward  AND  rightWall - position < oneStep)  OR
   (walkingBack  AND  position - leftWall < oneStep)
```

(B)
```
if (walkingForward  AND  rightWall - position < oneStep)  AND
   (walkingBack  AND  position - leftWall < oneStep)
```

(C)
```
if (walkingForward  AND  rightWall - position > oneStep)  OR
   (walkingBack  AND  position - leftWall > oneStep)
```

(D)
```
if (walkingForward  AND  rightWall - position > oneStep)  AND
   (walkingBack  AND  position - leftWall > oneStep)
```

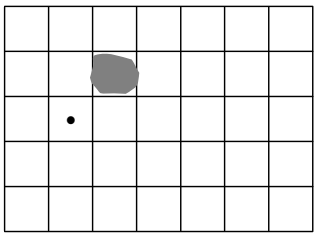
Answers and Solutions

Meet 1

1. C
2. 9
3. 5
4. 32 or 2^5
5 `odday` or `"odday"`
6 3

Solutions:

1. Just follow the arrows. The board after three commands looks like this:



which eliminates Choices A and B right away.

2. These are numbers represented in the binary (base 2) number system:

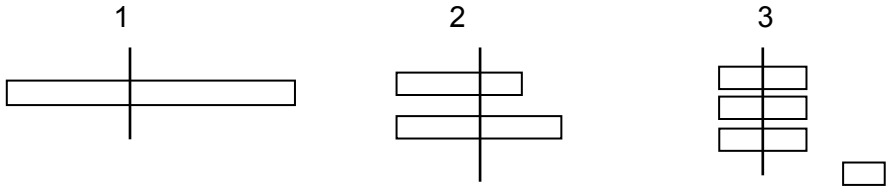
```
0001    1
0010    2
0011    3
0100    4
0101    5
0110    6
0111    7
1000    8
1001    9
```
(followed by)
```
1010    10
1011    11
```
etc.

3. If the entered number is greater than 5, the program displays the number minus 5 (otherwise it displays 1).

4. When we add one bit to the length of the code, the number of codes doubles, because each of the shorter codes now can be combined with a 0 and with a 1. So there are 16 different four-bit codes and 32 different five-bit codes.

5. `good" + "day"` makes `"goodday"`.
`"goodday".substring(2)` gives `"odday"` (skip the first two letters).

6.



Three is the smallest number of cuts possible: clearly we cannot have more than 4 pieces after two cuts.

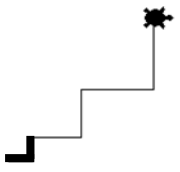
Meet 2

1. 1: ⇨ 2: ⇩ (in this order; words “right”, “down” are acceptable, too)
2. C
3. D
4. `11101`
5. B
6. 1, 3, and 4 (in any order)

Solutions:

1. After the first four commands, the only way to get to a painted square is ⇨. You need to go down twice to get to the third painted square.

2. You can guess the answer after looking at the first two lines in the picture, because the first two `move` commands remain the same as in the original program.



3. To compare two dates properly, we need to first compare the months and then, only if they are equal, compare the days.

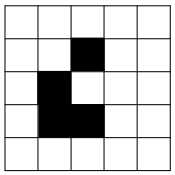
4. We need to untangle NOT (`01011` AND `10111`) OR NOT (`10000` OR `00110`).

   `01011` AND `10111` gives `00011`. NOT `00011` gives `11100`.
   `10000` OR `00110` gives `10110`. NOT `10110` gives `01001`.
   Finally, `11100` OR `01001` gives the answer, `11101`.

5. Because `user_input` includes both `"morning"` and `"evening"`, the conditions in both "if" statements will be true and the program will print first `"morning"`, then `"evening"`.

6. All the pictures in the left group have at least one black triangle.

Meet 3

1. C
2. 4 or `11010110`
3. A
4. 
5. 38
6. A

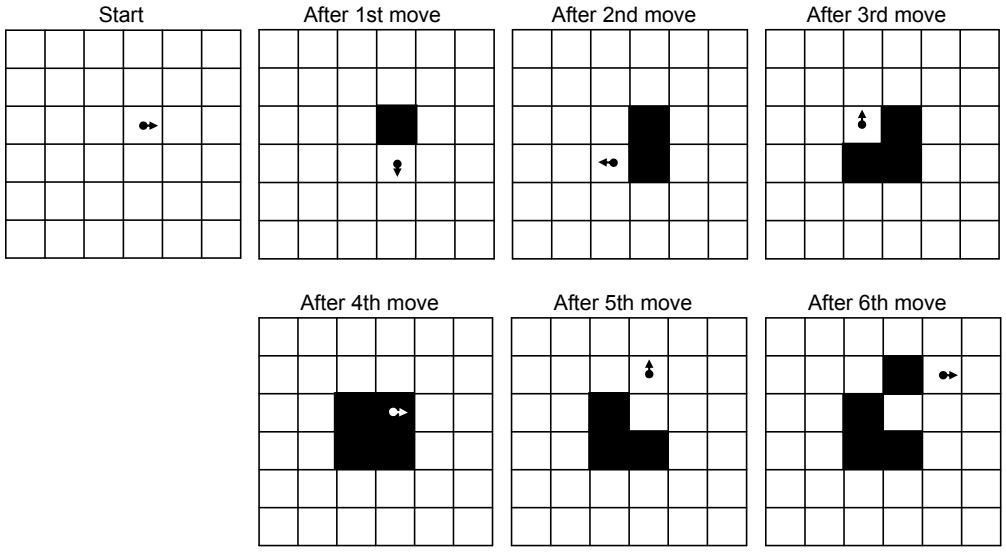
Solutions:

1. `3*[0]` makes `[0, 0, 0]`; then `[0, 0, 0] + [1, 2, 3]` makes `[0, 0, 0, 1, 2, 3]`

2. The byte number 4 has five bits set to 1, an odd number. The parity of all the other bytes is even.

3. Both programs work. Aaron's program goes row by row: first row forward, second row backward, and so on. Betty's program goes column by column: first column down, second column up, and so on.

4. The progression of moves:



(Langton's "ant" is an example of a *cellular automaton*. It behaves chaotically at the beginning, but later the pattern becomes regular, painting a wide diagonal shaft in the SE direction.)

5. 32 + 4 + 2

6. Peri is walking forward or walking back, not both at once, hence OR, not AND. When walking forward, Peri is walking toward the right wall and she has to make a U-turn when the remaining distance, `rightWall - position`, is less than one step.