CyberChallenge.IT 2026 - Pretest
Commented solutions

Contents

1 Question 1

1.1 Question

After a long day preparing for the CyberChallenge.IT finals, Alice really wants to order a pizza at her favorite place.

She knows that the pizzeria's phone number has exactly 10 digits, each between 0 and 9; she even remembers 9 digits but does not remember one, nor she remembers the position it occupies in the number. She does remember the relative order of the 9 digits she knows.

How many phone calls must Alice make, in the worst case, to be certain of knowing the correct number?

1.2 Answers

(A) `110`

(B) `90`

(C) `100`

(D) `10`

1.3 Proposed solution

The correct answer is `(B) 90`.

At first sight, one may think there are $10 \cdot 10 = 100$ possible phone numbers: the missing digit can be any of the 10 digits from 0 to 9, and it can be inserted in any of the 10 positions.
However, some of these possibilities coincide. Indeed, if the missing digit is equal to one of the remembered digits, then inserting it immediately before or immediately after that same digit may produce the same 10-digit number. More generally, if a digit d appears c_d times among the 9 remembered digits, then for that digit there are not 10 distinct insertions, but only $10 - c_d$ distinct phone numbers.
Therefore, the total number of possible phone numbers is

$$\sum_{d=0}^{9}(10 - c_d) = 100 - \sum_{d=0}^{9} c_d.$$

Since the 9 remembered digits contain a total of 9 digits, we have $\sum_{d=0}^{9} c_d = 9$, so the number of possible phone numbers is $100 - 9 = 91$.
In the worst case, Alice may need to try all possibilities except one: after 90 wrong calls, the only remaining number must be the correct one. Hence the answer is `90`.

2 Question 2

2.1 Question

A CTF team wants to buy custom team stickers.

Stickers cost one cent each. The team altogether has 500 coins, with some of them being one cent coins and some others being 5 cent coins. You know that they have at least one coin of each type, but you don't know exactly how many.

What is the difference between the maximum and the minimum number of stickers the team can afford?

2.2 Answers

(A) `1996`

(B) `2500`

(C) `2000`

(D) `1992`

2.3 Proposed solution

The correct answer is `(D) 1992`.

Let x be the number of 1-cent coins and y the number of 5-cent coins. Then

$$x + y = 500, \qquad x \geq 1,\ y \geq 1.$$

The number of stickers they can afford is the total value of the coins:

$$x + 5y = x + 5(500 - x) = 2500 - 4x.$$

This quantity is largest when x is as small as possible, namely $x = 1$, giving $2500 - 4 = 2496$. It is smallest when x is as large as possible, namely $x = 499$, giving $2500 - 4 \cdot 499 = 504$.
Hence the required difference is $2496 - 504 = 1992$.

3 Question 3

3.1 Question

During a CyberChallenge.IT admission quiz, there are 52 people in a room.

What is the largest integer n such that the statement below is certainly true?

"At least n people in this room have their birthday in the same month!"

3.2 Answers

(A) `4`

(B) `5`

(C) `6`

(D) `12`

3.3 Proposed solution

The correct answer is `(B) 5`.

There are 12 months and 52 people. By the pigeonhole principle, if we distribute 52 people among 12 months, at least one month must contain at least

$$\left\lceil \frac{52}{12} \right\rceil = 5$$

birthdays.
Moreover, 5 is the largest integer that is certainly guaranteed: for instance, it is possible to have 4 people in some months and 5 in the others, so we cannot guarantee 6.
Therefore, at least 5 people must have their birthday in the same month.

4 Question 4

4.1 Question

During a live quiz on TV, three contestants must answer a question secretly by writing it on a piece of paper. To prevent them from seeing a neighbor's paper, the host seats them in a single row of six numbered chairs with the rule that **no two contestants may sit next to each other**.

The contestants are distinct, and different seat numbers count as different arrangements.

In how many different ways can the host assign the contestants?

4.2 Answers

(A) `4`

(B) `18`

(C) `24`

(D) `60`

4.3 Proposed solution

The correct answer is `(C) 24`.

We first choose which 3 of the 6 chairs are occupied, under the condition that no two chosen chairs are adjacent. The possible sets of occupied chairs are:

$$\{1,3,5\}, \quad \{1,3,6\}, \quad \{1,4,6\}, \quad \{2,4,6\}.$$

So there are 4 valid ways to choose the seats.
Now the three contestants are distinct, so once the seats are chosen, they can be arranged in $3! = 6$ different ways.
Hence the total number of arrangements is $4 \cdot 6 = 24$.

5 Question 5

5.1 Question

For a cybersecurity conference, you are designing a 7×7 LED badge pattern using only two colors, black and white. The badge firmware requires the pattern to be perfectly symmetric, meaning the grid does not change with any of these operations:

- Rotating the grid around its center.
- Reflecting the grid across either diagonal.
- Reflecting the grid across the line connecting the midpoints of two opposite sides.

Also, the grid is not monochrome: at least one square is black and at least one square is white.

How many different 7×7 grids satisfy these conditions?

5.2 Answers

(A) `1022`

(B) `1024`

(C) `512`

(D) `2046`

5.3 Proposed solution

The correct answer is `(A) 1022`.

Because the grid must remain unchanged under all the given symmetries, some squares are forced to have the same color. We can group together all squares that must be equal, and label them with the same number.
A possible labeling is:

10	9	7	4	7	9	10
9	8	6	3	6	8	9
7	6	5	2	5	6	7
4	3	2	1	2	3	4
7	6	5	2	5	6	7
9	8	6	3	6	8	9
10	9	7	4	7	9	10

So there are exactly 10 independent groups of squares. Once we choose the color of each group, the whole board is determined.
Therefore the total number of symmetric colorings is $2^{10} = 1024$.
However, the grid is required to be non-monochrome, so we must exclude the all-black board and the all-white board. Hence the number of valid grids is 1024-2=1022.

6 Question 6

6.1 Question

At a cybersecurity conference, 4 people are talking. Their names are Alberto, Berto, Certo and Derto. Each of them can be either a white hat, who always tells the truth, a black hat, who always lies, or a grey hat, who alternates truths and lies. They say the following sentences:

- Alberto: "Berto is a grey hat" and then "Certo is a black hat"
- Berto: "Certo is a grey hat" and then "Derto is a black hat"
- Certo: "Derto is a grey hat" and then "Alberto is a black hat"
- Derto: "Alberto is a grey hat" and then "Berto is a black hat"

How many different values can the number of white hats take?

Clarification: being a grey hat means that after each true sentence the person says a false one and viceversa. They can choose if their first sentence is true or false, then they are forced to alternate between truth and lie.

6.2 Answers

(A) `1`

(B) `2`

(C) `3`

(D) `4`

6.3 Proposed solution

The correct answer is `(B) 2`.

We show that the number of white hats can only be 0 or 1.
Suppose first that Alberto is a white hat. Then both his statements are true, so:

$$\text{Berto is grey,} \qquad \text{Certo is black.}$$

Now Berto is grey, so his two statements must have opposite truth values. Since "Certo is grey" is false, the second one must be true, so Derto is black.
Thus we get the configuration

$$(\text{Alberto}, \text{Berto}, \text{Certo}, \text{Derto}) = (W, G, B, B).$$

By symmetry, whenever there is a white hat, the whole configuration is forced up to rotation, so there is exactly *one* white hat.
On the other hand, it is also possible to have no white hats at all: for example, all four can be grey hats, choosing their first sentence true and second false. Indeed, (G, G, G, G) is consistent.
Therefore the possible numbers of white hats are exactly 0 and 1. Hence the number of different values is 2.

7 Question 7

7.1 Question

At a large CTF event, there are 2026 participants. Each participant wears a hat that can be either black or white.
Each participant is asked to compute the ratio between

- the number of participants wearing a hat of a *different* color than theirs
- the number of participants wearing a hat of the *same* color as theirs (including themselves).

Let each participant compute this ratio based on the actual hat distribution.
How many *distinct values* can the sum of all these computed ratios take?

7.2 Answers

(A) `1`

(B) `2`

(C) `2025`

(D) `2026`

7.3 Proposed solution

The correct answer is `(B) 2`.

Let w be the number of white hats and b the number of black hats, with $w + b = 2026$. A participant with a white hat computes the ratio $\frac{b}{w}$, since there are b hats of the other color and w hats of the same color (including their own).
Similarly, a participant with a black hat computes $\frac{w}{b}$.
Therefore, if both colors are present, the sum of all ratios is

$$w \cdot \frac{b}{w} + b \cdot \frac{w}{b} = b + w = 2026.$$

If instead all hats have the same color, then every participant sees 0 hats of a different color, so each ratio is 0, and the total sum is 0.
Hence the sum can take exactly two distinct values: 0 and 2026.

8 Question 8

8.1 Question

There are n people sitting around a circular table. Each person is either a *white hat*, who always tells the truth, or a *black hat*, who always lies. Everyone knows the type of every other person at the table.

You interview them one by one:

- When asked what they themselves are, **everyone answers that they are a white hat**.
- When asked about the person sitting to their right, **everyone answers that this person is a black hat**.

You then ask a randomly chosen person how many people are sitting at the table, and they answer **37**.

Next, you ask the same question to the person sitting to their right: this person tells you **not to believe the previous answer**, claiming that it was given by a black hat, and says that **there are 40 people** at the table.

How many black hats are sitting at the table?

8.2 Answers

(A) `18`

(B) `20`

(C) `19`

(D) `37`

8.3 Proposed solution

The correct answer is `(B) 20`.

If a person is a white hat, then their statement about the person on their right is true, so the person on their right is a black hat. If a person is a black hat, then their statement about the person on their right is false, so the person on their right is actually a white hat.
Therefore, moving around the table, hat colors must alternate:

$$W, B, W, B, \dots$$

Hence the total number of people must be even, and exactly half of them are black hats.
Now consider the two special answers. Let the first interviewed person be P, and the person to their right be Q.
If Q were a black hat, then their claim that P is a black hat would be false, so P would be a white hat. Then P's answer "37" would be true, meaning there are 37 people at the table. But this is impossible, since the total number must be even.
So Q must be a white hat. Hence their statement is true: P is a black hat, and there are 40 people at the table.
Since the hats alternate, exactly half of the 40 people are black hats: $\frac{40}{2} = 20$.

9 Question 9

9.1 Question

A technical manual has all its pages numbered in order, starting from page 1.

While flipping through the book, the digit **1** appears exactly **9 times** in the page numbers.

How many pages does the book have?

9.2 Answers

(A) `14`

(B) `15`

(C) `16`

(D) `17`

9.3 Proposed solution

The correct answer is `(C) 16`.

Let us count how many times the digit 1 appears in the page numbers from 1 onward.
From page 1 to page 9, the digit 1 appears once:

$$1.$$

From page 10 to page 16, it appears as follows:

$$10\ (1),\quad 11\ (2),\quad 12\ (1),\quad 13\ (1),\quad 14\ (1),\quad 15\ (1),\quad 16\ (1).$$

So from 10 to 16 it appears

$$1 + 2 + 1 + 1 + 1 + 1 + 1 = 8$$

times.
Adding the contribution of page 1, the total up to page 16 is

$$1 + 8 = 9.$$

Therefore the book has `16` pages.

10 Question 10

10.1 Question

In a SOC (Security Operations Center), three analysts work in different shifts.

One analyst works only from **10:00 to 11:00**.
Another works from **13:00 to 19:00**.
The third analyst works only when *at least one* of the other two is working, **or** when one of them stopped working *at most one hour ago*.

How many hours of the day are there during which at least one analyst is working?

10.2 Answers

(A) `9`

(B) `10`

(C) `11`

(D) `12`

10.3 Proposed solution

The correct answer is `(A) 9`.

The first analyst works from

$$10{:}00 \text{ to } 11{:}00,$$

and the second one from

$$13{:}00 \text{ to } 19{:}00.$$

The third analyst works whenever at least one of the other two is working, or when one of them stopped working at most one hour ago.
So:

- after the first analyst stops at 11:00, the third may still work until 12:00;
- after the second analyst stops at 19:00, the third may still work until 20:00.

Hence the times during which at least one analyst is working are:

$$[10{:}00, 12{:}00] \quad \text{and} \quad [13{:}00, 20{:}00].$$

Their total length is

$$2 + 7 = 9$$

hours.
Therefore the answer is `9`.

11 Question 11

11.1 Question

Consider the following function

```
function f(x):
    x = x - ((x >> 1) & 0x5555)
    x = (x & 0x3333) + ((x >> 2) & 0x3333)
    x = (x + (x >> 4)) & 0x0F0F
    x = x + (x >> 8)
    return x & 0x001F
```

where numbers starting with `0x` are intended to be in base 16, and the `>>` and `&` operator are respectively the bitwise right shift and the bitwise and.

What is the sum of the value of $f(x)$ for x ranging from 0 to $2^{16} - 1$ (both included)?

11.2 Answers

(A) `32768`

(B) `131072`

(C) `262144`

(D) `524288`

11.3 Proposed solution

The correct answer is `(D) 524288`.

The function `f(x)` is a standard bit trick to count the number of 1's in the binary representation of x, i.e., its *population count*.
So we must compute

$$\sum_{x=0}^{2^{16}-1} f(x),$$

that is, the total number of 1 bits appearing in all 16-bit numbers.
Now fix one bit position. Among all 2^{16} binary strings of length 16, exactly half have a 1 in that position, so that bit contributes 2^{15} to the total sum.
Since there are 16 bit positions, the total is

$$16 \cdot 2^{15} = 16 \cdot 32768 = 524288.$$

Therefore the answer is `524288`.

12 Question 12

12.1 Question

Consider the following function that checks if an array is *unimodal*, i.e., an array that has a single peak (possibly repeated).

```
function f(A):
    n = length(A)
    if n <= 2:
        return true

    i = 0
    while i + 1 < n and A[i] <= A[i + 1]:
        i += 1

    while i + 1 < n and A[i] >= A[i + 1]:
        i += 1

    return (i == ??)
```

What should you insert instead of the `??` placeholder to make it correct?

Note: A is indexed starting from 0.

12.2 Answers

(A) `n-1`

(B) `n`

(C) `n+1`

(D) `2*n`

12.3 Proposed solution

The correct answer is `(A) n-1`.

The first `while` moves forward as long as the array is nondecreasing. The second `while` continues from there as long as the array is nonincreasing.
So the array is unimodal exactly when these two phases together reach the last valid index of the array, namely

$$n - 1.$$

If instead the process stops earlier, then somewhere the array increases again after having started decreasing, so it is not unimodal.
Therefore the correct condition is

`return (i == n-1).`

13 Question 13

13.1 Question

Consider the following incomplete pseudocode fragment:

```
for r = 0 to 5:
    for c = 0 to 7:
        if (??):
            print("A")
        else:
            print("B")
    print_new_line()
```

The expected output is:

```
AAAAAAAA
BAAAAAAB
BBAAAABB
BBBAABBB
BBBBBBBB
BBBBBBBB
```

What should you put instead of `??` to make it correct?

Note: the range of the for loop is inclusive on both sides.

13.2 Answers

(A) `(c > r) AND (c < 7 - r)`

(B) `(c >= r) AND (c <= 7 - r)`

(C) `(r > c) AND (r < 5 - c)`

(D) `(r + c >= 2) AND (r + c <= 9)`

13.3 Proposed solution

The correct answer is `(B) (c >= r) AND (c <= 7 - r)`.

Let us look at the rows one by one.
For row $r = 0$, the output is

`AAAAAAAA`,

so every column $c = 0, \ldots, 7$ must print `A`.
For row $r = 1$, only the first and last characters are `B`, so `A` appears for

$$1 \leq c \leq 6.$$

For row $r = 2$, `A` appears for

$$2 \leq c \leq 5.$$

For row $r = 3$, `A` appears for

$$3 \leq c \leq 4.$$

For rows $r = 4$ and $r = 5$, no value of c satisfies the condition, so the whole row is `B`.
Thus, in general, `A` must be printed exactly when

$$c \geq r \quad \text{and} \quad c \leq 7 - r.$$

So the correct choice is

`(c >= r) AND (c <= 7 - r)`.

14 Question 14

14.1 Question

Consider the following function:

```
function search(A, x):
    left = 0
    count = 0
    right = length(A) - 1

    while left <= right:
        count = count + 1
        mid = floor((left + right) / 2)

        if A[mid] == x:
            return count
        else if A[mid] < x:
            left = mid + 1
        else:
            right = mid - 1

    return count
```

What is the return of the function when `A` is the array `[1,2,2,3,3,3,4,..., 100]` (where each number n up to 100 included is written n times and the array is ordered), and $x = 37$?

Note: A is indexed starting from 0.

14.2 Answers

(A) `4`

(B) `5`

(C) `6`

(D) `7`

14.3 Proposed solution

The correct answer is `(D) 7`.

The array is

$$[1, 2, 2, 3, 3, 3, 4, \ldots, 100],$$

so the number n appears exactly n times.
Hence the total number of elements is

$$1 + 2 + \cdots + 100 = \frac{100 \cdot 101}{2} = 5050.$$

So initially:

$$\texttt{left} = 0, \qquad \texttt{right} = 5049.$$

We now simulate the binary search.

count	mid	A[mid]	action
1	2524	71	right = 2523
2	1261	50	right = 1260
3	630	36	left = 631
4	945	43	right = 944
5	787	40	right = 786
6	708	38	right = 707
7	669	37	found

So the function returns 7.

To justify the values of the array: the number 37 occupies positions from

$$1 + 2 + \cdots + 36 = 666$$

up to

$$666 + 36 = 702,$$

so index 669 indeed contains 37.

15 Question 15

15.1 Question

Consider the following code:

```
k = 0

for i = 0 to 100:
    for j = i to 200:
        if (j-i) mod 4 == 0:
            k = k+1
print(k)
```

What does it print?

Note: the condition in the if means that `j-i` must be a multiple of 4. Moreover, the range in both the for loops is inclusive on both sides.

15.2 Answers

(A) `3851`

(B) `5076`

(C) `3994`

(D) `4531`

15.3 Proposed solution

The correct answer is `(A) 3851`.

For a fixed value of i, the variable j ranges from i to 200, and we count only the values such that

$$j - i \equiv 0 \pmod 4.$$

So we can write

$$j = i + 4t$$

for some integer $t \geq 0$, and the condition $j \leq 200$ becomes

$$i + 4t \leq 200 \quad \Longrightarrow \quad t \leq \left\lfloor \frac{200 - i}{4} \right\rfloor.$$

Therefore, for each fixed i, the number of valid values of j is

$$\left\lfloor \frac{200 - i}{4} \right\rfloor + 1.$$

Hence

$$k = \sum_{i=0}^{100} \left(\left\lfloor \frac{200 - i}{4} \right\rfloor + 1 \right).$$

Now let $m = 200 - i$. As i goes from 0 to 100, m goes from 200 down to 100, so

$$k = 101 + \sum_{m=100}^{200} \left\lfloor \frac{m}{4} \right\rfloor.$$

For $m = 100, \ldots, 199$, each integer from 25 to 49 appears exactly 4 times, and for $m = 200$ we get 50. Thus

$$\sum_{m=100}^{200} \left\lfloor \frac{m}{4} \right\rfloor = 4(25 + 26 + \cdots + 49) + 50.$$

Now

$$25 + 26 + \cdots + 49 = \frac{(25 + 49) \cdot 25}{2} = 925,$$

so

$$4 \cdot 925 + 50 = 3700 + 50 = 3750.$$

Therefore

$$k = 101 + 3750 = 3851.$$

So the program prints `3851`.