CyberChallenge.IT 2019 - Test
Commented solutions

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1 Question 1

1.1 Question

Given the following piece of code:

```
char src[20] = "Paperino";
char* dest = malloc(/* COMPLETE */);
strcpy(dest, src);
```

Complete the `malloc` so that `dest` points to the smallest memory area that can accommodate the string `src`:

1.2 Answers

(A) `sizeof(src)`

(B) `strlen(src)`

(C) `strlen(src)+1`

(D) `sizeof(src)+1`

1.3 Proposed solution

The correct answer is `(C) strlen(src)+1`.

The size of the requested memory area be enough to contain all the letters of "Paperino" (and their number is computed as `strlen(src)`). But we must not forget that strings in C are null terminated, so there must be room for the terminating null byte, for a total of `strlen(src)+1` bytes.

2 Question 2

2.1 Question

Which of the following expressions is always true?

2.2 Answers

(A) `sizeof(int) == 4`

(B) `sizeof(int *) == sizeof(int)`

(C) `sizeof(long) == sizeof(int)`

(D) `sizeof(char) == 1`

2.3 Proposed solution

The correct answer is `(D) sizeof(char) == 1`.

The size of an integer and of a pointer is machine dependent, while the C standard[1] prescribes that `char`, `unsigned char` and `signed char` all have size equals to 1.

[1] See section 6.5.3.4, point 4 of `https://www.open-std.org/jtc1/sc22/WG14/www/docs/n1570.pdf`

3 Question 3

3.1 Question

What is the output of this program?

```
void one_char_forward(char** pointer){
    pointer++;
}

int main(){
    char* str = malloc(1000*sizeof(char));
    strcpy(str, "This is a CyberChallenge Quiz!");
    one_char_forward(&str);
    puts(&str);
    free(str);
    return 0;
}
```

3.2 Answers

(A) "This is a CyberChallenge Quiz!"

(B) "his is a CyberChallenge Quiz!"

(C) Compiler error

(D) Garbage value

3.3 Proposed solution

The correct answer is `(D) Garbage value`.

The function `one_char_forward` does not have any effect since it is modifying just its local variable. Therefore the pointer to the string is left unchanged.

There still be an issue, with the function `puts`: it should be called with a pointer to a string as argument, but in the fragment the address of the pointer is used instead. The result is that the output would be the value of the pointer (i.e. the address of the string in memory) interpreted as an array of characters, thus a sequence of random symbols.

4 Question 4

4.1 Question

Consider the following C program:

```c
#define N 3
#define M 4

void f(int* x) {
    printf("%d\n", ...);
}

int main() {
   int x[N][M] = {{1,2,3,4},{5,6,7,8},{9,10,11,12}};
   f(x);
}
```

What would you put in place of `...`, so that the function `f()` outputs the value of `x[1][2]` (i.e., the number 7)?

4.2 Answers

(A) `*(*(x + 1) + 2)`

(B) `*(*(x + 2) + 1)`

(C) `*(x + 1 * M + 2)`

(D) `*(x + 2 * M + 1)`

4.3 Proposed solution

The correct answer is `(C) *(x + 1 * M + 2)`.

Matrices in C are stored in row-major order[2]. This means that the matrix `x` is stored with its elements ordered from 1 to 12.

The element `x[1][2]` is on the second row, third column. The size of a row is `M`, so we need to skip `M` elements in order to move to the second column. Other 2 elements are to be skipped, so that the third column is accessed.

The offset is therefore `1*M + 2`, so the element 7 is accessed as `*(x + 1*M + 2)`.

[2] See `https://en.wikipedia.org/wiki/Row-_and_column-major_order`

5 Question 5

5.1 Question

Consider the two C expressions `x & 255` and `x % 256`. Which of the following is correct?

5.2 Answers

(A) the two expressions are never interchangeable

(B) the two expressions are always interchangeable regardless of the type of `x`

(C) the two expressions are always interchangeable if `x` is an unsigned integral variable

(D) the two expressions are never interchangeable unless `x` is a floating-point variable

5.3 Proposed solution

The correct answer is `(C) the two expressions are always interchangeable if x is an unsigned integral variable`.

In fact, if `x` is signed and negative, the bitwise AND will return a positive number, while the modulo operator will return a negative one. Moreover, if `x` is a floating-point variable, the bitwise AND does not behave as a modulo operation, because of the internal structure of this type of variable.

6 Question 6

6.1 Question

What is the purpose of the following function?

```
int myfun(int x, int y){
    if (y == 0)
        return x;
    else
        return myfun( x ^ y, (x & y) << 1);
}
```

Remember that `x ^ y` denotes the bitwise XOR of `x` and `y`, `x & y` denotes their bitwise AND, and `<<` is the left shift.

6.2 Answers

(A) Summing the values of `x` and `y`

(B) Subtracting the values of `x` and `y`

(C) Multiplying the values of `x` and `y`

(D) None of the above options

6.3 Proposed solution

The correct answer is `(A) Summing the values of x and y`.

Let us show that `myfun` is computing the value of `x + y`.

In binary, the addition of two bits behaves in the following way:

x	y	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Let us notice that the column of the sum is the same as the one of the bitwise XOR, while the carry behaves like the bitwise AND.

Finally, the left shift is needed to sum each carry with the bits in the correct position.

To sum up, the function is recursively doing the sum without carries (the XOR), calculating the bit array of carries (the AND and the left shift) and repeating the whole process until there is no carry, thus adding the two values `x` and `y`.

7 Question 7

7.1 Question

What can we deduce from the sentence “All the computers have a CPU and a memory”?

7.2 Answers

(A) If a machine only has a memory, then it is not a computer.

(B) If a machine is a computer, then it has a CPU and a memory.

(C) If a machine only has a CPU, then it is not a computer.

(D) All of the other answers are valid.

7.3 Proposed solution

The correct answer is `(D) All of the other answers are valid.`

The starting assumption is that all the computers have a CPU and a memory, thus if one of these two components is missing, then we cannot define that machine a computer. This means that answers `(A)` and `(C)` true.

Moreover, since it is equivalent to the starting assumption, also answer `(B)` is true, so all of the first three answers are true.

8 Question 8

8.1 Question

I'm 5 years older than my sister, who is 7 years younger than Lucy. How old was Lucy when her age was equal to the sum of ours?

8.2 Answers

(A) 2

(B) 7

(C) 9

(D) 10

8.3 Proposed solution

The correct answer is `(C) 9`.

Let us call with m, s, l my age, my syster's one and Lucy's one respectively. Then we have:

$$\begin{cases} m - s = 5 \\ l - s = 7 \\ m + s = l \end{cases}$$

that has $(m, s, l) = (7, 2, 9)$ as solution.

9 Question 9

9.1 Question

There is a set of actions, labeled from A to G. B and D requires A (that is, A must be executed before we can execute either B or D). F and G require D; F requires G too. C requires B, while A requires E. Finally, F requires C. If you execute all actions, respecting these dependencies, which is the last action that you can start?

9.2 Answers

(A) A

(B) B

(C) C

(D) D

(E) E

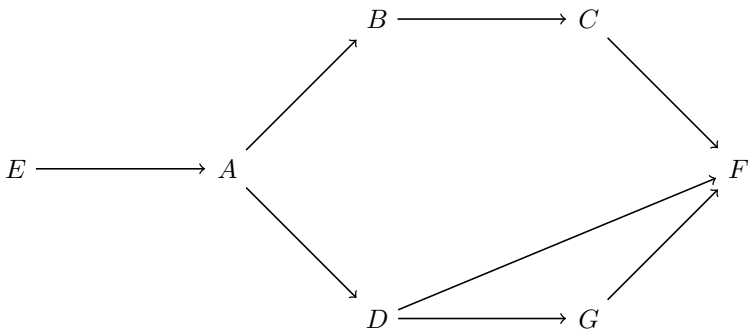
(F) F

(G) G

9.3 Proposed solution

The correct answer is `(F) F`.

The dependencies tree is depicted below:



It is clear that the last action to be executed is necessarily F.

10 Question 10

10.1 Question

A peach tree is left with only two branches, with one higher than the other. A few birds are resting perched on its branches. If right now a bird hops on the lower branch, the birds on the lower branch become twice as many as the ones on the higher one. However, if a bird hops instead on the upper branch, the number of birds perched on each branch becomes the same. How many birds are now on the lower branch?

10.2 Answers

(A) 5

(B) 6

(C) 7

(D) 8

(E) 9

10.3 Proposed solution

The correct answer is `(C) 7`.

Let us call with u, l the number of birds on the upper and lower branches, respectively. Then we have:

$$\begin{cases} 2 \cdot (u-1) = l+1 \\ u+1 = l-1 \end{cases}$$

that has $(u, l) = (5, 7)$ as solution.

11 Question 11

11.1 Question

CyberSec Inc. is a multinational technology company that employs thousands of people around the world. The salary of the company's CEO is 30 times the average salary of an over 45-year-old software engineer. Moreover, it is known that

- There are 1000 software engineers working for CyberSec in total, with an average salary of \$80K (per year).
- There are 2000 employees who are over 45 years old, and their average salary is \$65K (per year).
- There are 2700 "expensive employees" in total, where an "expensive employee" is a software engineer or any person over 45 years of age.
- The total wage bill for expensive employees is \$180.9 million (per year).

What is the salary of CyberSec's CEO?

11.2 Answers

(A) \$2.1 million

(B) \$2.91 million

(C) \$2.33 million

(D) \$2.01 million

11.3 Proposed solution

The correct answer is `(B) $2.91 million`.

Let us call with e, s, b the number of employees over 45 years old, software engineers and over 45-year-old software engineers, respectively. Then we have:

$$\begin{cases} s + b = 1000 \\ e + b = 2000 \\ s + e + b = 2700 \end{cases}$$

that has $(s, e, b) = (700, 1700, 300)$ as solution.

Moreover, let E, S, B be their wages, in the same order as before. We have:

$$\begin{cases} \dfrac{s \cdot S + b \cdot B}{s + b} = 80K \\ \dfrac{e \cdot E + b \cdot B}{e + b} = 65K \\ s \cdot S + e \cdot E + b \cdot B = 180.9M \end{cases} \Leftrightarrow \begin{cases} s \cdot S + b \cdot B = 80M \\ e \cdot E + b \cdot B = 130M \\ s \cdot S + e \cdot E + b \cdot B = 180.9M \end{cases}$$

We can subtract the third equation from the sum of the other two in order to obtain $300B = 80M + 130M - 180.9M = 29.1M$. Since the CEO earns 30 times B, its wage is $30B = 2.91M$.

12 Question 12

12.1 Question

There are 5 houses in 5 different colors, each owned by a person with a different nationality. These owners drink a certain type of beverage, smoke a certain brand of cigar and keep a certain pet. No one has the same pet, smokes the same brand of cigar or drinks the same beverage. Moreover,

1. The Englishman lives in the red house.
2. The Spaniard owns the dog.
3. Coffee is drunk in the green house.
4. The Ukrainian drinks tea.
5. The green house is immediately to the right of the ivory house.
6. The Old Gold smoker owns snails.
7. Kools are smoked in the yellow house.
8. Milk is drunk in the middle house.
9. The Norwegian lives in the first house.
10. The man who smokes Chesterfields lives in the house next to the man with the fox.
11. Kools are smoked in the house next to the house where the horse is kept.
12. The Lucky Strike smoker drinks orange juice.
13. The Japanese smokes Parliaments.
14. The Norwegian lives next to the blue house.

Who owns the zebra?

12.2 Answers

(A) The Norwegian

(B) The Ukrainian

(C) The Japanese

(D) The Englishman

12.3 Proposed solution

The correct answer is `(C) The Japanese`.

Analyzing the clues, we can reconstruct the entire configuration[3]. For example, by clue 1, clue 5, clue 9 and clue 14, we can deduce that the Norwegian lives in the yellow house (and therefore, by clue 7, the Norwegian smokes Kools).

Using similar reasonings, the following table can be built:

House	**1**	**2**	**3**	**4**	**5**
Color	Yellow	Blue	Red	Ivory	Green
Nationality	Norwegian	Ukrainian	Englishman	Spaniard	Japanese
Drink	Water	Tea	Milk	Orange juice	Coffee
Smoke	Kools	Chesterfields	Old Gold	Lucky Strike	Parliaments
Pet	Fox	Horse	Snails	Dog	Zebra

[3]See `https://en.wikipedia.org/wiki/Zebra_Puzzle`