CyberChallenge.IT 2018 - Pretest
Commented solutions

Contents

1 Question 1

1.1 Question

Function `search` is supposed to return 1 if `x` belongs to an ordered array `v` of size `n`, and 0 otherwise:

```
int search(int* v, int n, int x) {
    int a = 0, b = n;
    while (a < b) {
        int m = ...;
        if (v[m] == x) return 1;
        if (v[m] < x) a = m + 1;
        else b = m;
    }
    return 0;
}
```

What would you put in place of `...`?

1.2 Answers

(A) a-1

(B) b+1

(C) (a+b)/2

(D) (b-1)/2

1.3 Proposed solution

The correct answer is `(C) (a+b)/2`.

The function `search` is performing a binary search[1] inside the ordered vector `v` and that algorithm requires, in order to be efficient in the average and worst case, to compare `x` with the element halfway between the extremes `a` and `b`, which has index $\frac{a+b}{2}$.

[1]See `https://en.wikipedia.org/wiki/Binary_search_algorithm`

2 Question 2

2.1 Question

What does `int (*x[10])();` mean in C?

2.2 Answers

(A) x is a pointer to an array of 10 functions without arguments that return int

(B) x is an array of 10 pointers to functions without arguments that return int

(C) x is a function without arguments that returns and array of 10 pointers to int

(D) x is an array of 10 functions that return a pointer to int

2.3 Proposed solution

The correct answer is `(B) x is an array of 10 pointers to functions without arguments that return int`.

In fact, `x` is an array of 10 pointers (`(*x)[10]`) to functions without arguments (`(*x[10])()`) that return int (`int (*x[10]())`).

3 Question 3

3.1 Question

What does the following C function do?

```
void foo(char v[4]) {
    int* p = (int*)v;
    *p = (*p & 0x000000FF) << 24 |
         (*p & 0x0000FF00) << 8  |
         (*p & 0x00FF0000) >> 8  |
         (*p & 0xFF000000) >> 24;
}
```

Assume that `sizeof(int)` is 4.

3.2 Answers

(A) computes a checksum of all bytes of array `v`

(B) reverses the content of array `v`

(C) rotates the content of array `v`

(D) the code is wrong

3.3 Proposed solution

The correct answer is `(B) reverses the content of array v`.

The function `foo` selects the first, second, ... byte with the bitwise AND and moves them to the fourth, third, ... positions with the shifts. The result is that the order of the four bytes pointed by `p` is reversed and therefore the chars (whose size is one byte) of `v` are in reversed order.

4 Question 4

4.1 Question

Consider the following C function:

```c
1 int* mycalloc(int n) {
2    int *p = malloc(n*sizeof(int)), *q;
3    for (q=p; q<=p+n; ++q) *q = 0;
4    return p;
5 }
```

Which of the following is correct?

4.2 Answers

(A) The program is correct

(B) There is an error at line 1

(C) There is an error at line 2

(D) There is an error at line 3

(E) There is an error at line 4

4.3 Proposed solution

The correct answer is `(D) There is an error at line 3`.

The for loop inside the function iterates `n+1` times, and thus overwrites the 4 bytes adjacent to `p` in memory.

The correct form of that line is `for (q=p; q<p+n; ++q) *q = 0;`.

5 Question 5

5.1 Question

Let `int x, y` be two integers that represent Boolean values (zero means false, and a non-zero value means true). How would you check in C that `x` is true **if and only if** `y` is true?

5.2 Answers

(A) `(x && !y) || (y && !x)`

(B) `(x == y) || !x && !y`

(C) `(!x == !y) && !x || !y`

(D) `(x || !y) && (y || !x)`

5.3 Proposed solution

The correct answer is `(D) (x || !y) && (y || !x)`.

The only expression that has the correct truth table is `(x || !y) && (y || !x)`.

For all the other expressions, it is possible to provide a counterexample:

- for `(x && !y) || (y && !x)`, `x` true and `y` true returns false;
- for `(x == y) || !x && !y`, `x` false and `y` false returns true;
- for `(!x == !y) && !x || !y`, `x` true and `y` true returns false.

6 Question 6

6.1 Question

During a recruitment interview, you are asked to write your own version of the standard `strlen` function:

```
unsigned mystrlen(const char* s) {
    unsigned cnt = 0;
    ...
    return cnt;
}
```

Would you put in place of ...?

6.2 Answers

(A) `do { cnt++; s++; } while(*s != '\0');`

(B) `while (s[cnt]) { s++; cnt++; }`

(C) `while (*s++) cnt++;`

(D) `while (s[cnt++]);`

6.3 Proposed solution

The correct answer is `(C) while (*s++) cnt++;`.

`while (*s++) cnt++;` works as expected, while:

- `do { cnt++; s++; } while(*s != '\0');` returns 1 if the string is empty;
- `while (s[cnt]) { s++; cnt++; }` returns $\frac{l+1}{2}$, if l is the real length of the string;
- `while (s[cnt++]);` returns $l+1$ if l is the real length of the string.

7 Question 7

7.1 Question

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

7.2 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

7.3 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.

8 Question 8

8.1 Question

Let `y` be a `double` in C and let `x = (long)(y + 0.5)`. Which of the following is correct?

8.2 Answers

(A) `x` is obtained by rounding `y` to the nearest integer

(B) `x` is the smallest integer larger than `y`

(C) `x` is the largest integer smaller than `y`

(D) `x` is equal to `y` if and only if `y-0.5` is integral

(E) `x-y` is always equal to `0.5`

8.3 Proposed solution

The correct answer is `(A) x is obtained by rounding y to the nearest integer`.

We can write $x = \left\lfloor y + \frac{1}{2} \right\rfloor$, so `x` is equal to a certain value `x'` if and only if $x' <= y + \frac{1}{2} < x' + 1$, i.e. $x' - 0.5 <= y < x' + 0.5$, which is how the rounding to the nearest integer is performed.

9 Question 9

9.1 Question

Consider the following two C functions:

```
int foo(const int* v, unsigned n, int x) {
    if (n == 0) return 0;
 L: if (v[--n] == x) return 1;
    if (n > 0) goto L;
    return 0;
}

int bar(const int* v, unsigned n, int x) {
    int i;
    for (i = 0; i < n; i++)
        if (v[i] == x) return 1;
    return 0;
}
```

Which of the following is correct?

9.2 Answers

(A) `foo` and `bar` are always interchangeable

(B) `foo` and `bar` are never interchangeable

(C) `foo` and `bar` are interchangeable only if `n` is non-zero

(D) `foo` and `bar` are interchangeable only if `x` does not belong to `v`

9.3 Proposed solution

The correct answer is `(A) foo and bar are always interchangeable`.

Both the two functions traverse the vector `v` of size `n` linearly looking for `x`, `foo` from the end to the beginning and `bar` vice-versa. The behaviour is exactly the same, thus the two functions are always interchangeable.

10 Question 10

10.1 Question

The following function is supposed to compute the sum of all even numbers up to `n` if `n` is even, and the sum of all odd numbers up to `n` if `n` is odd:

```
unsigned sum_even_odd(unsigned n) {
    if (n == 0) return 0;
    return n + sum_even_odd(n-2);
}
```

Which of the following is correct?

10.2 Answers

(A) the function always returns the expected value

(B) the function works correctly only if `n` is odd

(C) the function works correctly only if `n` is even

(D) the function never returns the expected value

10.3 Proposed solution

The correct answer is `(C) the function works correctly only if n is even`.

Let us notice that the function returns only if `n == 0` and it calls itself with argument `n-2`, thus the parity of the argument of `sum_even_odd` never changes. Therefore, if `n` is odd, the function never returns, while, if `n` is even, it works as expected.

11 Question 11

11.1 Question

If you write down all the numbers from 300 to 400, how many times do you have to write the digit 3?

11.2 Answers

(A) 100

(B) 109

(C) 110

(D) 120

11.3 Proposed solution

The correct answer is `(D) 120`.

The number 400 has no digits equals to 3, so we can exclude it from our reasoning. Every number in the range $[300, 399]$ has the digit 3 as its hundreds digit, which gives us 100 occurrences. Moreover, $\frac{1}{10}$ of the tens digits are 3 and $\frac{1}{10}$ of the units digits are 3, for a total of $100 + 10 + 10 = 120$ occurrences of the digit 3.

12 Question 12

12.1 Question

There are 27 tennis balls. 26 of them have the same weight and the twenty-seventh is a bit heavier. In the worst case scenario, what is the minimum number of weighings you need to identify the heavy one by using a two-pan balance scale?

12.2 Answers

(A) 2

(B) 3

(C) 4

(D) 5

(E) 6

12.3 Proposed solution

The correct answer is `(B) 3`.

The best strategy is to divide the balls into 3 groups, let us say A, B, C, and compare two of them with the balance scale. Without loss of generality, we compare the weights of A and B. If one of them is heavier than the other, we know that the ball we have to find is in that group. Otherwise, if the two groups have the same weight, the ball is in group C.

With this strategy, we restricted the entire set of balls to one third of the initial size. By iterating it, the heaviest ball is identified in 3 weighings.

13 Question 13

13.1 Question

Pedro is a contestant on a "Deal or No Deal" game, and he's given the choice of three boxes: inside one box is a one million prize, while the others are empty. He picks a box, say No. 1, and the host, who knows what's inside the boxes, opens another box, say No. 3, which is empty. He then asks him, "Do you want to pick box No. 2 instead?" Is it to his advantage to switch his choice?

13.2 Answers

(A) yes

(B) no

(C) it's the same

(D) it's the onion

13.3 Proposed solution

The correct answer is `(A) yes`.

The answer is yes[2]. Ignoring the numbers of the boxes, there are three cases, and each one has probability $\frac{1}{3}$:

- Pedro chooses the first empty box, the host opens the second one and Pedro wins the prize by switching his choice;
- Pedro chooses the second empty box, the host opens the first one and Pedro wins the prize by switching his choice;
- Pedro chooses the prize, the host opens one of the empty boxes and Pedro wins the money keeping his choice.

In 2 cases over 3 Pedro wins the prize if he change his mind, improving the probability (of $\frac{1}{3}$) of choosing the prize at the beginning.

Formally, let us denote by P_2 the event "the prize is inside box No. 2" and by E_3 the event "the box No. 3 is empty"; we can say that $P(E_3) = \frac{1}{2}$, since Pedro chose box No. 1 and the host has to open one of the two boxes, and $P(E_3 \mid P_2) = 1$ because the host has to open box No. 3 if the prize is in box No. 2. Now we can exploit Bayes theorem to compute

$$P(P_2 \mid E_3) = \frac{P(E_3 \mid P_2)P(P_2)}{P(E_3)} = \frac{1 \cdot \frac{1}{3}}{\frac{1}{2}} = \frac{2}{3}$$

[2]See `https://en.wikipedia.org/wiki/Monty_Hall_problem`

14 Question 14

14.1 Question

A director wishes to know how many times their movie has been shown in a given theater. The theater's staff provides the following info:

- at the first projection there's just 1 viewer;
- at each projection, the number of viewers grows by 1 compared to the previous one;
- 820 tickets are sold over all the projections. How many projections were held?

14.2 Answers

(A) 13

(B) 20

(C) 40

(D) 81

14.3 Proposed solution

The correct answer is `(C) 40`.

Let us denote the number of projections of the movie with n. If the number of viewers grows by one each time, the total number of tickets sold will be $1 + 2 + 3 + \ldots + n = \sum_{i=1}^{n} i = \frac{n(n+1)}{2}$. Given that 820 tickets are sold, we need to solve for n the equation $\frac{n(n+1)}{2} = 820$, which leads to $n = 40$.

15 Question 15

15.1 Question

You can paddle your canoe 7 miles per hour through any placid lake. You're paddling through the Wabash river and the stream constantly flows at 3 miles per hour. The moment you start to paddle up stream, a fisherman looses one of his fishing bobbers in the water 14 miles up stream of you. How many hours does it take for you to reach the bobber?

15.2 Answers

(A) 1.5

(B) 2

(C) 2.5

(D) 3

15.3 Proposed solution

The correct answer is `(B) 2`.

Let us pick as reference system the river's water. Then, your speed is 7 miles per hour, while the water bobber does not move. Since the initial distance is 14 miles, the time needed to reach the bobber is $\frac{14}{7} = 2$.

16 Question 16

16.1 Question

A man has 53 socks in his drawer: 21 identical blue, 15 identical black and 17 identical red. The lights are fused and he is completely in the dark. How many socks must he take out to make 100 per cent certain he has a pair of black socks?

16.2 Answers

(A) 21

(B) 36

(C) 40

(D) 48

16.3 Proposed solution

The correct answer is `(C) 40`.

The worst case is when the man picks all the blue and red socks before picking a pair of black ones. This means that with $21 + 17 + 2 = 40$ socks he will be 100% sure to have a pair of black socks.

17 Question 17

17.1 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?

17.2 Answers

(A) 2

(B) 7

(C) 9

(D) 10

17.3 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. Than 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.

18 Question 18

18.1 Question

The Spring Festival is a great occasion for getting to know other people in town, if you know how to dance. Last year, a number of foreigners were traveling by and joined the festival. Each dancer got to perform their favourite dance with their partners. Hans and Linda were fantastic together. Gustavo chose tango, while Javier performed amazingly at the rumba. Lexi watched the waltz, and Ben excelled at the foxtrot. Rebecca danced with Gustavo, while Monica did not dance with Javier. Which dance was picked by Monica?

18.2 Answers

(A) Tango

(B) Foxtort

(C) Waltz

(D) Rumba

18.3 Proposed solution

The correct answer is `(B) Foxtrot`.

From the hints, it immediately follows that Gustavo and Rebecca danced the tango, while Ben and Javier danced the foxtrot and the rumba, respectively. It follows that Hans and Linda danced the waltz, since it is the only dance with two free spots for the couple.Since Monica did not dance with Javier, her partner is Ben, thus she danced the foxtrot (and Lexi danced the rumba with Javier).

19 Question 19

19.1 Question

Consider the problem of drawing a square using for each edge either a blue pencil, or a red pencil. How many different square can we obtain, considering as equal squares obtained from each other by rotation?

19.2 Answers

(A) 4

(B) 6

(C) 8

(D) 10

(E) 12

19.3 Proposed solution

The correct answer is `(B) 6`.

Let us divide the problem into cases, looking at how many edges are, for example, red:

- 0 red edges: there is just one configuration;
- 1 red edge: there is one configuration, as all the others can be obtained by a rotation;
- 2 red edges: there are two configurations, one with the red edges that are touching each other and the other one with the red and blue edges that alternates;
- 3 or 4 red edges: this case follow from the cases with 1 and 0 red edges by symmetry, giving one configuration each.

In total, there are $1 + 1 + 2 + 1 + 1 = 6$ different squares.

20 Question 20

20.1 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?

20.2 Answers

(A) The Norwegian

(B) The Ukrainian

(C) The Japanese

(D) The Englishman

20.3 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`