02393 C++ Programming Exercises

Optional exercises for assignment 3

To be handed in via Autolab — `https://autolab.compute.dtu.dk/courses/02393-E23/assessments`

1 Sorted or not?

Write a program that:

1. reads an integer $n \geq 0$ from the standard input (`cin`);
2. then reads n positive integers;
3. finally, the program outputs `SORTED` if the n integers were given in increasing order, or `UNSORTED` otherwise.

Note. Depending on how you write your code, you might need special cases for $n = 0$ and/or $n = 1$; in such cases, the program must output `SORTED` (a sequence of numbers of length 0 or 1 is obviously sorted).

2 Largest number

Write a program that:

1. reads an integer $n \geq 0$ from the standard input (`cin`);
2. then reads n positive integers;
3. finally, the program outputs the n integers separated by one space, highlighting the largest with `*` on its left and right. If the largest number appears multiple times, then the program must highlight its first occurrence, only.

For example, if the program input is:

```
6 10 3 55 2 1 55
```

Then the program output should be:

```
10 3 *55* 2 1 55
```

3 Dot product

If u and v are two vectors of length n, then their *dot product* $u \cdot v$ is defined as:

$$u \cdot v \;=\; \sum_{i=1}^{n} u_i v_i$$

Write a program that reads two vectors and outputs their dot product, as follows:

1. first, the program reads an integer $n \geq 1$ representing the length of both vectors;
2. then, it reads n `double` values, representing the first vector;
3. then, it reads n more `double` values, representing the second vector;
4. finally, it outputs the dot product of the two vectors.

Note. The dot product should be computed using `double`s and stored in a `double` variable.

For example, if the program input is:

```
3 1 2 3 4 5 6
```

Then the program output should be:

4 Histogram

A *histogram* represents the distribution of a dataset into discrete intervals. Consider for instance the data set given by the integer numbers 100 95 47 88 86 92 75 89 81 70 55 80; suppose we want build a histogram with 11 intervals $[0-10)$, $[10-20)$, ..., $[100-110)$ to be textually represented as follows: *(meaning: there are 0 numbers in the interval* $[0-10)$*, and 5 numbers in* $[80-90)$*, etc.)*

```
0: 0
10: 0
20: 0
30: 0
40: 1
50: 1
60: 0
70: 2
80: 5
90: 2
100: 1
```

Write a program that reads the following values (in this order) from the standard input (cin):

- the number ℓ of intervals (e.g. 11 in the example above)
- the size n of the data set (e.g. 12 in the example above)
- and n non-negative integers

and then outputs the histogram in the above format.

Hints. Let each interval have integer size $k = \lceil \frac{m}{\ell} \rceil$, where m is the maximum number in the data set. That is, interval i should be $[(i-1) \times k \ldots i \times k)$. The function $\lceil \cdot \rceil$ is implemented as function ceil() in the library math.h

As an example, the input for the histogram above (11 intervals, 12 values) is:
`11 12 100 95 47 88 86 92 75 89 81 70 55 80`
hence, we have $k = \lceil \frac{100}{11} \rceil = \lceil 9,0909 \ldots \rceil = 10$, and thus the i-th interval starts at $(i-1) \times 10$. E.g., the last interval (11-th) starts at $(11-1) \times 10 = 100$. You can see it in the output above.

Another example: with the same data above but interval size $\ell = 7$ we have the input:
`7 12 100 95 47 88 86 92 75 89 81 70 55 80`
hence the intervals size is $\lceil \frac{100}{7} \rceil = \lceil 14,2857 \ldots \rceil = 15$, and the resulting output is:

```
0: 0
15: 0
30: 0
45: 2
60: 1
75: 6
90: 3
```

Special case. Consider the input: `2 4 8 6 3 1`. Here the maximum number $m = 8$ in the dataset can be divided by the number of intervals $l = 2$. Technically, the second (and last) interval should be $[4, 8)$, thus excluding 8 from the histogram. To solve this problem, we need to check for a special condition: if m can be divided by l, then we include m in the last interval. This way, for the input `2 4 8 6 3 1` we obtain the histogram:

```
0: 2
4: 2
```
rather than:
```
0: 2
4: 1
```