

CS2.201: Computer Systems Organization
Spring 2024
International Institute of Information Technology, Hyderabad

CSO Lab Exam Questions

Note: Read the given information below carefully.

- There are 12 problems in this question bank.
- Only attempt those questions which are assigned to you
- Assume signed/unsigned long long int or double based on the question.
- Tentative marks problem 1 to 6: 15 marks for each question; from problem 7 to 12: 25 marks for each.
- Comments: Not necessary. But some comments to guide us in evaluations would help. Note: Only some basic comments are enough. Don't add comments for each line. It would take too much of your time and would actually make it difficult for us to find the main parts of your code. So if adding comments, just add a few comments near the main parts of your code.
- Naive solution is fine. However, the solution should be reasonable enough. It shouldn't be too complicated too. For example, if you are asked to sort, we don't expect you to use merge sort. You can use a naive algorithm like bubble sort which solves the problem in $O(n^2)$. But if you come up with something overly complicated like a $O(n^3)$ or $O(n^4)$ solution and as a result of which your code fails to run even on small/simple test cases, then that can attract penalties.
- You must strictly stick to the **input and output formats**.
- Your C file can contain only inputs, outputs and memory allocations. Everything else should be in a function defined in assembly which will be invoked from C file.
- No need to handle invalid input cases unless explicitly asked to handle them in the question.

Submission format: Strictly adhere to the following submission format. Failure to do so may result in an erroneous evaluation of your exam. A minimum of -5 marks would be used as penalty if the submission instructions are not followed properly plus there is a good likelihood that your submission would not be evaluated if significant efforts are involved.

- The following directory structure is expected,

```
./<roll_number>
├── qa
│   ├── qa.s
│   └── qa.c
└── qb
    ├── qb.s
    └── qb.c
```

- For example if you are assigned question 2 and 8 and your roll number 2023101001 then the following submission is expected.

```
2023101001
├── q2
│   ├── q2.s
│   └── q2.c
└── q8
    ├── q8.s
    └── q8.c
```

Problem 1: Given two numbers(N and M) perform basic arithmetic operations, i.e. add, subtract, divide, exponentiation, modulus- using switch case(S) or if-else.

Input/Output Format

- Input: M N S
- Output: Result of chosen operation in integer format
- Switch case: '1' for addition($M+N$), '2' for subtract($M-N$), '3' for divide(M/N), '4' for exponentiation(M^N), and '5' for modulus($M\%N$)

Sample Test Case

Input: 7 5 2

Output: 2

Problem 2: Check if a given 64-bit number contains odd number of 1s in its bit representation.

Input/Output Format

- Input: N
- Output: **TRUE**, if the input has odd number of 1s, **FALSE** otherwise.

Sample Test Case

Input: 5

Output: FALSE

Input: 7

Output: TRUE

Explanation- Bit representation of 5 is 101, i.e. even number of 1s. Hence, output is FALSE. Similarly, bit representation of 7 is 111, i.e. odd number of 1s. Hence, output is TRUE.

Problem 3: Given a positive integer N, return an array of integers with all the integers from 1 to N. But for multiples of 3 the array should have -1 instead of the number, for multiples of 5 the array should have -2 instead of the number, and for multiples of both 3 and 5 the array should have -3 instead of the number.

Input/Output Format

- Input: N
- Output: N numbers from 1 to N with modifications as required

Sample Test Case

Input: 5

Output: 1 2 -1 4 -2

Input: 17

Output: 1 2 -1 4 -2 -1 7 8 -1 -2 11 -1 13 14 -3 16 17

Problem 4: Given a number N, check if it is a palindrome or not.? Palindromes are those numbers which read the same backward and forward. 1, 363, 1331 are palindromes while 10, 456 are not.

Input/Output Format

- Input: N, Single Integer to be checked.
- Output: **True**, if it is a palindrome; **False**, if not.
- Note: Output case does not matter, TrUe, true, TRUE all are acceptable.

Sample Test Case

Input: 13931

Output: True

Input: 69

Output: False

Problem 5: Given an array of binary digits i.e. array consisting only of 0s and 1s, rearrange the elements of array in such a way that all the 0s come before 1s in the array. You need to do this in linear time.

Input/Output Format

- Input: Contains two lines. First line has a single integer N, the size of the array; Second line contains N integers where each integer is either 0 or 1
- Output: Rearranged array as required in the question.

Sample Test Case

Input:

5

0 1 1 0 1

Output:

0 0 1 1 1

Input:

4

0 1 0 0

Output:

0 0 0 1

Problem 6: Given two numbers M and N, find GCD(M,N)

Input/Output Format

- Input: M N
- Output: Integral value of the GCD
- Note: $0 < M, N < INT_MAX$

Sample Test Case

Input: 24 39

Output: 3

Problem 7: Given an array A of size N and a positive integer B, pick **x** elements from the left end of the array and **y** elements from the right end of the array, where $x + y = B$, such that sum of those elements is the **maximum possible sum** that can be achieved while meeting the constraints mentioned above.

Note: $0 \leq x, y \leq B$.

Input/Output Format

- Input: Has two lines. First line contains two integers N (size of the array) and B. Next line contains N space-separated integers which are elements of the array.
- Output: One integer, maximum possible sum.

Sample Test Case

Input:

5 3

5 -2 3 1 2

Output:

8

Input:

2 1

1 2

Output:

2

Problem 8: Given an array of N integers, sort the array into a wave-like array and return it. In other words, arrange the elements into a sequence such that $a_1 \geq a_2 \leq a_3 \geq a_4 \dots$

Note: If multiple answers are possible, return the lexicographically smallest one.

Input/Output Format

- Input: Has two lines. First line contains single integer N, size of the array. Next line contains N space-separated integers which are elements of the array.
- Output: Wave form of input array.

Sample Test Case

Input:

4

1 2 3 4

Output:

2 1 4 3

Input:

2

1 2

Output:

2 1

Problem 9: Given an **unsorted** array of N integers, find the first missing **positive** integer.

Input/Output Format

- Input: Has two lines. First line contains a single integer N , size of the array. Next line contains N space-separated integers which are elements of the array.
- Output: Single integer, first missing positive integer

Sample Test Case

Input:

3

2 1 0

Output:

3

Input:

4

3 4 -1 1

Output:

2

Problem 10: You are given array a of length N . You can perform the following operation as many number of times as you want:

Pick two integers i and j ($1 \leq i, j \leq N$) such that $a_i + a_j$ is **odd**, then swap a_i and a_j

Output lexicographically smallest array possible which can be obtained by performing above operation any number of times.

Input/Output Format

- Input: Has two lines. First line contains a single integer N , size of the array. Next line contains N space-separated integers which are elements of the array.
- Output: Lexicographically smallest array which can be obtained by performing above operations any number of times.
- **Note:** No need to minimize the number of operations, just obtain the lexicographically smallest array possible.

Sample Test Case

Input:

3

4 1 7

Output:

1 4 7

Input:

4

4 2 6 8

Output:

4 2 6 8

Problem 11: There are n people standing in line, each looking left or right. Each person counts the number of people in the direction they are looking. The value of the line is sum of each person's count. You are given initial arrangement of people in the line. For **each k from 1 to n** , determine the maximum value of line if you can change the direction of **at most** k people.

Input/Output Format

- Input: Has two lines. First line contains a single integer N , size of the array. Next line contains N space-separated integers which are elements of the array. Each integer can either be 0 or 1.
0 - Looking left, 1 - Looking right.
- Output: N integers, i^{th} integer is the maximum value of line if you can change direction of at most i people for each i from 1 to n .

Sample Test Case

Input:

3

0 0 1

Output: 3 5 5

Input:

9

0 1 0 1 0 1 0 1 0

Output:

44 50 54 56 56 56 56 56 56

Problem 12: Given a number N , check if the sum of the factorial of digits is equal to N (special number).

Input/Output Format

- Input: N
- Output: **TRUE**, if the input is special number, **FALSE** otherwise.

Sample Test Case

Input: 145

Output: TRUE

Explanation- $1! + 4! + 5! = 145$

ALL THE BEST