

# COL100

## Introduction to Computer Science

### Assignment 2

## 1 Treasure Hunt

A group of adventurers is on a treasure hunt with a map. The map has a 4-digit PIN and symbols for instructions. The first 4 digits of the PIN represent North, South, East, and West directions. The adventurers only use the numbers 1, 2, 3, and 4 in the PIN. The subsequent line in the map data indicates the count of navigational instructions to follow, which is 5 in the given example. Following this, the next five lines present pairs of numbers. The first number designates the direction, while the second number specifies the distance to travel in that particular direction. Write a C program that takes the map data as input and outputs the following information

1. Total distance travelled by the team
2. Their displacement from the starting point
3. The quadrant of their location in cartesian coordinates, assuming the starting point is at (0,0). Assume that N-S direction aligns with the Y-axis with N in the +Y direction. In case the final location does not belong to any quadrant, print -1

### 1.1 Sample Input

```
3214
5
3 20
1 40
2 10
4 40
2 40
```

### 1.2 Sample Output

```
150
(0, -30)
-1
```

### 1.3 Explanation

The order in which they travel is as follows: 20 units North, 40 units East, 10 units South, 40 units West, and finally 40 units South. As a result of these movements, they have travelled a distance of 150 units and they find themselves at a distance of **30 units** from their starting point.

## 2 Binary Operations using Conditional Statement

Given 2 inputs each of one is a 4 bits binary number, where 1st input will be MSB and 4th input will be LSB of 4 bits number, you have to perform the following binary operations : **Addition, XOR, AND and OR using conditional statements(if else) only** and output the result in binary representation.

### 2.1 Sample Input

```
0 0 1 1
1 1 1 0
```

### 2.2 Sample Output

```
10001
1101
0010
1111
```

### 2.3 Explanation

As first input is  $a = 0011$  and 2nd input is  $b = 1110$ , then Binary addition of  $a$  and  $b$  :  $a + b = 10001$ , similarly  $a \oplus b = 1101$ ,  $a \text{ AND } b = 0010$  and  $a \text{ OR } b = 1111$ .

### 2.4 Note

You are **not** allowed to use any bitwise operators, you can use logical operators but only for checking the conditions ( in if else syntax) in your code.

## 3 Analysis of Streams of Numbers

Given a stream of positive numbers as input and once -1 is encountered as input assume that stream ends. You are required to output 3-tuples for each number  $n$  in the stream, these 3 tuples are used to represent the count of set bits in  $n$ , count of numbers from set

$\{1, 2, \dots, n-2, n-1\}$  which are relatively prime (coprime) to  $n$ , whether  $n$  is Mersenne prime or not (i.e., 1 if  $n$  is Mersenne prime and 0 if it is not).

### 3.1 Definitions

**Set bits** in binary number is represented by 1

**Relatively prime / Coprime :** Two number  $a$  and  $b$  are said to be Relatively prime/ Coprime if their gcd is 1 i.e.,  $\gcd(a, b) = 1$

**Mersenne prime :** A prime number which can be represented in the form of  $2^n - 1$

### 3.2 Formula for Coprime calculation :

You can use following formula for Co-prime calculation :

If  $n = p_1^{a_1} * p_2^{a_2} * p_3^{a_3} * \dots * p_r^{a_r}$ , where  $p_1, p_2, \dots, p_r$  are prime factors of  $n$ .

Then count of numbers  $< n$  which are relative prime/coprime to  $n$  is given by  $n * (1 - \frac{1}{p_1}) * (1 - \frac{1}{p_2}) * (1 - \frac{1}{p_3}) * \dots * (1 - \frac{1}{p_r})$

### 3.3 Sample Input

3 4 5 -1

### 3.4 Sample Output

(2, 2, 1)  
(1, 2, 0)  
(2, 4, 0)

### 3.5 Explanation

For input 3, we know that its binary representation is 11, hence number of 1 in binary representation of 3 is 2, Hence count of set bits (number of occurrence of 1 in binary representation) for 3 is 2

As  $\gcd(1, 3) = 1$ ,  $\gcd(2, 3) = 1$ , hence count of number from set  $\{1, 2\}$  which are relatively prime (coprime) to 3 is 2

As 3 is a prime number and it can be represented as  $2^2 - 1 = 3$ . Hence 3 is Mersenne prime , so our answer will be 1.

Hence final 3-tuple for 3 will be (2,2,1).