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CSE 331

Computer Organizations

Homework 1

Due Date 04/11/2022 Friday 17:00

1. A compiler designer wants to improve the performance of a machine for one specific program. The program has the following properties:

	R-type (x10^6)	I-Type (x10^6)	J-Type (x10^6)
Program instructions	50	30	20

	R-type	I-Type	J-Type
Required Cycles	2	4	3

Assume you can improve only one type with 50%. Which type do you prefer for improvement and how many times can you improve the whole program in the end?

Performance is determined by execution time. But not just one of the variables are indicative to determine performance.

$$\text{Execution time} = \text{Instruction Count} * \text{CPI} / \text{Clock Rate(Mhz)}$$

Instructions in cycle per instructions (CPI) and instruction count cancels each other. So;

$$Execution\ Time = \frac{Total\ Clock\ Cycle}{Clock\ Rate}$$

To find number of total clock cycle, we need to use instructions and required cycles.

$$Total\ Cycles = 2 \times 50 \times 10^6 + 4 \times 30 \times 10^6 + 3 \times 20 \times 10^6 = 280 \times 10^6$$

Because of total cycles of I type is larger than others, improving it 50% makes bigger difference.

$$Total\ Cycles = 2 \times 50 \times 10^6 + 6 \times 45 \times 10^6 + 3 \times 20 \times 10^6 = 430 \times 10^6$$

At the end the performance we get is;

$$\frac{430 - 280}{280} \times 100 = 53.5\%$$

2. In this part you will write an assembly program on MARS for finding and printing all divisible sum pairs as explained below:

Given an array of integers and a positive integer k, determine the number of (i, j) pairs where $i < j$ and $ar[i] + ar[j]$ is divisible by k.

Example

$ar = [1, 2, 3, 4, 5, 6]$

$k = 5$

Three pairs meet the criteria: $[1, 4]$, $[2, 3]$, and $[4, 6]$.

Function Description

Complete the divisibleSumPairs function in the editor below.

divisibleSumPairs has the following parameter(s):

- int n: the length of array ar
- int ar[n]: an array of integers
- int k: the integer divisor

Returns

- int: the number of pairs

Input Format

The first line contains 2 space-separated integers, n and k.

The second line contains n space-separated integers, each a value of $arr[i]$.

Constraints

- $2 \leq n \leq 100$
- $1 \leq k \leq 100$
- $1 \leq ar[i] \leq 100$

Sample Input

```
STDIN          Function
-----          --------
6 3            n = 6, k = 3
1 3 2 6 1 2    ar = [1, 3, 2, 6, 1, 2]
```

Explanation

Here are the 5 valid pairs when $k = 3$:

- $(0, 2) \rightarrow ar[0] + ar[2] = 1 + 2 = 3$
- $(0, 5) \rightarrow ar[0] + ar[5] = 1 + 2 = 3$
- $(1, 3) \rightarrow ar[1] + ar[3] = 3 + 6 = 9$
- $(2, 4) \rightarrow ar[2] + ar[4] = 2 + 1 = 3$
- $(4, 5) \rightarrow ar[4] + ar[5] = 1 + 2 = 3$