Problem Set 3 Exercise #13: Estimate PI

Reference: Lecture 7 notes

Learning objective: One-dimensional array

Estimated completion time: 50 minutes

Problem statement:

This problem is adopted from National Software Competition 2006 for junior college students. (Copyright: NSC 2006.)

Professor Robert A.J. Matthews of the Applied Mathematics and Computer Science Department at the University of Aston in Birmingham, England, has recently described how the positions of stars across the night sky may be used to deduce a surprisingly accurate value of π. This result followed from the application of certain theorems in number theory.

Here, we don't have the night sky, but we can use the same theoretical basis to form an estimate for π.

Given any pair of positive integers chosen from a large set of random numbers, the probability that these two integers having no common factor other than one is $6/\pi^2$.

For example, using this small set of five numbers {2, 3, 4, 5, 6}, there are 10 pairs that can be formed: (2,3), (2,4), (2,5), (2,6), (3,4), (3,5), (3,6), (4,5), (4,6) and (5,6). Six of these 10 pairs - (2,3), (2,5), (3,4), (3,5), (4,5), and (5,6) - have no common factor other than one. Using the ratio of the counts as the probability we have:

$6/\pi^2 = 6/10$. Hence the estimated value of π is 3.1623, correct to four decimal places.

As another example, given this set of 10 numbers {32391, 14604, 3902, 153, 292, 12382, 17421, 18716, 19718, 19895}, there are 24 pairs that have no common factor other than one, among a total of 45 pairs. We have:

$6/\pi^2 = 24/45$. Hence the estimated value of π is 3.3541, correct to four decimal places.

Write a program **estimate_PI.c** that reads in a positive integer n representing the size of the list, followed by n unique positive integers (representing the random numbers). Your program then prints out an estimate value for π (using **double** type) accurate to 4 decimal places.

Your program should contain a function

```
double estimate_PI(int list[], int n)
```

that takes in an array **`list`** of **`n`** integers and returns the estimated value of π.

A tip is given at the end of next page.

Sample run #1:

```
Enter the size of the list: 3
Enter 3 elements: 7 4 10
Estimated pi = 3.0000
```

Sample run #2:

```
Enter the size of the list: 5
Enter 5 elements: 2 3 4 5 6
Estimated pi = 3.1623
```

Useful tip:

Write a function to compute the Greatest Common Divisor (GCD). This function needs to be efficient to pass all the test cases. Search online for an efficient GCD algorithm if necessary.