

Lecture 2

Math, Number Theory and Counting

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Abstract. This lecture is a part of competitive programming training lectures prepared for Eastern University, Dhaka. The lecture mainly serves as an introduction to competitive programming and algorithmic problem solving, the basics of C++ Programming Language and the commonly used C++ Standard Template Library (STL) functionalities.

1 An Introduction to Competitive Programming

- Solve problems based on mathematics, algorithms, data structures etc.
- Handle timed environment.
- Common verdicts of online judge platforms
 - AC (Accepted)
 - WA (Wrong Answer)
 - TLE (Time Limit Exceeded)
 - MLE (Memory Limit Exceeded)
 - Compilation Error
 - Presentation Error
- Assume 100000000 (1e8) operations per second

2 Basics of C++

- Basic I/O
- Data types, Variables
- Arrays
- Conditional statements
- Loops
- Functions
- Structures

3 Time Complexity Analysis, Big O

– Common time complexities:

- Constant time: $O(1)$

```
1 int x = 5;
2 cout << "hello world\n";
3 cin >> x;
4 for (int i = 1; i <= 10; i++) {
5     cout << "hello\n";
6 }
7 //the loop runs constant number of times
```

Listing 1.1. Example of Constant Time

- Linear time: $O(N)$

```
1 int n;
2 cin >> n;
3 for (int i = 1; i <= n; i++) {
4     cout << "hello\n";
5 }
```

Listing 1.2. Example of Linear Time

- Quadratic time: $O(N^2)$

```
1 int n, m;
2 cin >> n >> m;
3 for (int i = 1; i <= n; i++) {
4     for (int j = 1; j <= m; j++) {
5         cout << "hello\n";
6     }
7 }
```

Listing 1.3. Example of Quadratic Time

- Exponential time: $O(2^N)$

```
1 //finding the nth fibonacci results initially 2
  function calls.
2 //the function calls later each do 2 other function
  calls
3 //so, it ends up becoming exponential
4 int fibobacci(int n) {
5     if (n <= 2) return 1;
6     return fibonacci(n - 1) + fibonacci(n - 2);
7 }
```

Listing 1.4. Example of Exponential Time

- Logarithmic time: $O(\log(N))$

```
1 //looping x number of times such that y^x = n
2 //in other words, we loop the number of times can we
  divide n by y till n becomes 0
3 int n;
4 cin >> n;
5 for (int i = n; i > 0; i /= 2) {
6     cout << "hello";
7 }
8 }
```

Listing 1.5. Example of Logarithmic Time

4 The C++ Standard Template Library (STL)

- std::pair
- std::vector
- std::sort
- std::set
- std::map
- std::stack
- std::queue
- Research other STL functionalities

5 Long Contest - 1