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: $O(1)$

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

Listing 1.1. Example of Constant Time

- Linear time: $O(N)$

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

Listing 1.2. Example of Linear Time

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

```
int n, m;
cin >> n >> m;
for (int i = 1; i <= n; i++) {
    for (int j = 1; j <= m; j++) {
        cout << "hello\n";
    }
}
```

Listing 1.3. Example of Quadratic Time

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

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

Listing 1.4. Example of Exponential Time

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

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

Listing 1.5. Example of Linear 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