Prerequisites

Modern cpp Programming lecture 0

Practice basic cpp features!!

- Contents
  - basic features of cpp
  - standard input / output
  - loop statement
  - condition statement
  - basic function call
  - array
  - recursion

iostream

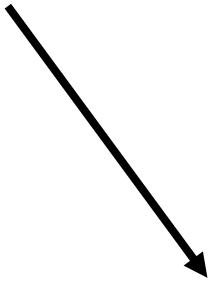
- `#include`
  - includes library or other files (module)
  - allow you to use functions / data in other module
  - `#include <iostream>`
    - you can use basic functionalities provided by `<iostream>` library!
    - iostream library includes functions for standard input / output.
      - `cout` : prints data in a console (standard output)
      - `endl` : ends line with newline character
        - » `endl` also empties output stream (don't need to know now)
      - `cin` : reads data from a console (standard input)

Standard input / output

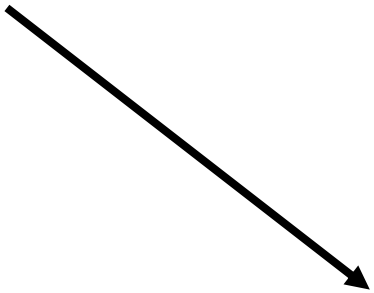
```
int number;

cin >> number;

cout << number << endl;
```

cf) \n : newline character (Enter key)

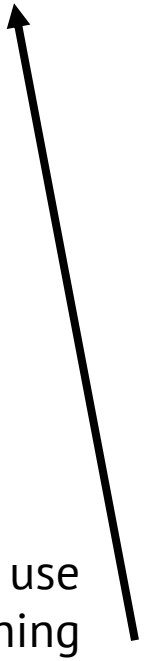
standard input



standard output



without endl, we cannot use
next line to print something
cf) you can just print "\n" instead



```
cout << "Hello, ";
cout << "World!!" << endl;

>> Hello, World!!
```

```
cout << "Hello, " << endl;
cout << "World!!" << endl;

>> Hello,
   World!!
```

Newline character

- \n : newline character

```
cout << “hello, \n world!!” << endl;
```

```
>> hello,
   world!!
```

- **In Korean windows, represented as ₩n…**
- \ (or ₩) locates below backspace
- \ (backslash) is used to represent various escape sequences:
  - \n : newline
  - \t : tab
  - \b : backspace
  - \r : move cursor to the starting point of line

namespace

- a set of symbols which organizes objects of various kind
- simple example!!
  - dog (of Alice)
  - dog (of Bob)
  - If we just write “dog”, we cannot differentiate two dogs
  - but if we write **“Alice :: dog”, “Bob :: dog”,** now two dogs can be dif ferentiated easily

namespace

- `using namespace std`
  - “I’ll use objects and functions in std (standard) namespace”
  - ex) cout, cin…
  - declare every c++ standard library function

```
using namespace std;

int main() {
   cout << “Hello, world!! << endl;
   return 0;
}
```

or

```
#include <iostream>
using namespace std;

int main() {
   std :: cout << “Hello, world!! << std ::endl;
   return 0;
}
```

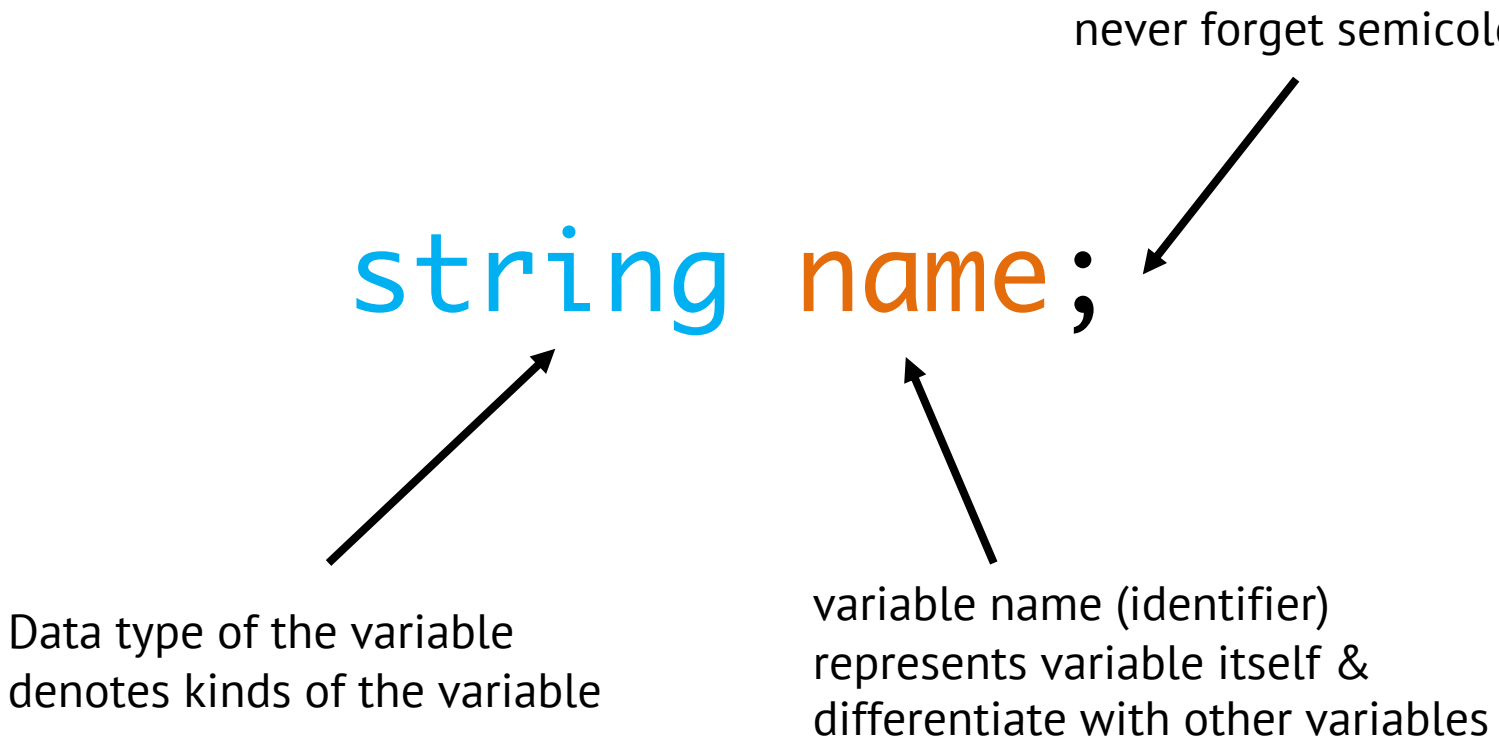
Programming!!

- Problem 1
- sample code available at
  - https://github.com/jeonhyun97/cpp_4_undergraduates/blob/master/cpp/lecture0/code/1_hello_world.cpp
- write program which reads your name with standard input
- and say hello to you!!
- output should be like this:

```
>> Your name: hyeon
   hello, hyeon!!
```

Data type

- In the prev example, you might saw such syntax…
- `string name;`
- Let's look careful…



Primitive data types

- Basic data types of cpp
  - int : represents integer
  - float : represents real number **(floating point)**
  - bool : Boolean, denotes true or false
  - char: denotes single alphabet
    - ex) a, b, 1, 5, &…
  - void: typeless
    - you'll see…

Primitive data types

- Data type is really important!!
- especially for static language
  - determine the type of variables at compile time
  - ex) c, cpp, Java
  - essential to write “data type” for every variable
- cf) dynamic language
  - no need to write data type
  - ex) javascript
    - `let num = 1;`
    - `let name = ”cpp”;` => every variable can be declared with ”let”

cpp string

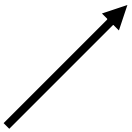
- String is not a primitive type
- Supports ”sequence of characters”
- but you should be familiar to it
- can be used by including `<string>` header
- declared as `std::string`
  - `using namespace std` will help you use string syntax in alone.

Data type – warning!!

- Data type can make significant error!!

```
#include <iostream>

using namespace std;

int main() {
    char aChar = 97;
    int aInt = 97;

    cout << aChar << endl;    >> a
    cout << aInt << endl;     >> 97
}
```

as ”97” is the number which encodes alphabet “a” in cpp



For more information, refer https://en.wikipedia.org/wiki/ASCII

Then, what does “main” mean??

```
int main() {
    cout << “Hello, word!! << endl;
    return 0;
}
```

we will come back…after we study “function”
for now, just think as an essential part to execute certain program

Cpp Operator

- Assignment operator
  - “=“
  - assigns value to a variable
  - you can assign value at declaration, or after declaration
    - `int num = 1;`
    - `int num;`

      `num = 1;`

Cpp Operator

- Arithmetic operators
  - Addition (+)
  - Subtraction(-)
  - Multiplication(*)
  - Division (/)
    - if real number : acts as common division
    - if integer : returns quotient
    - `float num = 3;  cout << (num / 2) << endl;  >> 1.500000`
    - `int num = 3;  cout << (num / 2) << endl;  >> 1`
  - Remainder(%)
    - `int num = 19;  cout << (num % 8) << endl;  >> 3`

Cpp Operators

- Special assignment operators
  - `a += b;`
  - ⇔ `a = a + b;`
  - `a -= b;`
  - ⇔ `a = a - b;`
  - `a *= b;`
  - ⇔ `a = a * b;`
  - `a /= b;`
  - ⇔ `a = a / b;`

Cpp Operators

- Increment / Decrement operators
  - ++,-- : increments / decrements 1
  - `a = 2; a++;` => a becomes 3
  - however, a++ and ++a is different!!

```
// postfix increment operator
int a = 2;
cout << a++ << endl;   >> 2
cout << a << endl;     >> 3
```

```
// prefix increment operator
int a = 2;
cout << ++a << endl;   >> 3
cout << a << endl;     >> 3
```

  - postfix : uses (returns) original value at the line
  - prefix : use (returns) modified value at the line

Cpp Operators

- Relational operators
  - <, >, <=, >= : common operators
  - != : true when two operands are different, otherwise false
  - == : true when two operands are same, otherwise false
  - Examples will help you

```
cout << (1 < 3)  << endl;    >> 1 (which means True)
cout << (1 > 3)  << endl;    >> 0 (which means False)
cout << (1 <= 1) << endl;    >> 1
cout << (3 >= 1) << endl;    >> 1
cout << (1 != 1) << endl;    >> 0
cout << (1 != 2) << endl;    >> 1
cout << (1 == 1) << endl;    >> 1
cout << (1 == 2) << endl;    >> 0
```

Cpp Operators

- Logical operators
  - and : &&
  - or : | |
  - not : !
  - evident (middle school mathematics…)
  - again, examples will help you!!

```
cout << (true  &&  true)  << endl;              >> 1
cout << (false &&  true)  << endl;              >> 0
cout << (false ||  true)  << endl;              >> 1
cout << (false || false)  << endl;              >> 0
cout << (!false)          << endl;              >> 1
cout << (!false || false) << endl;              >> 1
cout << ((!false || false) && true) << endl;    >> 1
cout << ((1 < 3) && (4 == 4)) << endl;          >> 1
```

Cpp Operators

- Order of operators
  - we should perform multiplication before addition…

    if there is no parenthesis.
  - Rule b/w operators is very important!!
  - Able to make significant error!!
  - However, you don’t need to memorize the order
  - you can easily search it, or just simple use parenthesis to make certain ordering

Cpp operators

1	() [] -> . ::	Function call, scope, array/member access
2	! ~ - + * & sizeof *type cast* ++ --	(most) unary operators, sizeof and type casts (right to left)
3	* / % MOD	Multiplication, division, modulo
4	+ -	Addition and subtraction
5	<< >>	Bitwise shift left and right
6	< <= > >=	Comparisons: less-than and greater-than
7	== !=	Comparisons: equal and not equal
8	&	Bitwise AND
9	^	Bitwise exclusive OR (XOR)
10	|	Bitwise inclusive (normal) OR
11	&&	Logical AND
12	||	Logical OR
13	? :	Conditional expression (ternary)
14	= += -= *= /= %= &= |= ^= <<= >>=	Assignment operators (right to left)
15	,	Comma operator

Loop statement

- you might want to print number 1~100
- how about…

```
cout << 1 << endl;
cout << 2 << endl;
cout << 3 << endl;
cout << 4 << endl;
…
cout << 100 << endl;
```

- inefficient!!
- You should order you program to…
- loop through numbers and print them

Loop statement

- `for` statement

A (initialization) B (condition) D (changement)

```
for (int i = 0; i < 10; i++) {
    cout << i << endl;
}
```

C (body)

- execution order: A -> B -> C -> D -> B -> C -> D -> B -> C -> D...
- This statement is saying...
  - first, initialize variable `i` as 0 (A)
  - print `i` (C) while incrementing it, (D)
  - until `i` is no longer smaller than 10 (B)

Loop statement

- while statement

```
let i = 0;
while (i < 10) {
    cout << i << endl;
    i++
}
```

A (initialization)

B (condition)

C (body)

D(body)

- execution order : same with for-loop
  - A -> B -> C -> D -> B -> C -> D…
  - initialization (A) should be performed before the loop
  - increment should be wrote explicitly in the body

Loop statement

- do-while statement

```
          A
let i = 0;
do {
     cout << i << endl; C
     i++ D
} while (i < 10) B
```

- execution order
  - A -> C -> D -> B -> C -> D -> B…
  - condition statement (B) performs after body statements (C, D)

Loop statement

- continue
  - stop current body execution

```
for (int i = 0; i < 5; i++) {
    cout << i << endl;
    continue;  // ends current body execution
    cout << i << endl; // never executed
}

output:
0
1
2
3
4
```

Loop statement

- break
  - stops entire loop (escape from the loop)

```
for (int i = 0; i < 5; i++) {
    cout << i << endl;
    break;  // ends loop
}
```

```
output:
0
```

After single execution of cout, the loop ends due to break statement

Programming!!

- Problem 2 ~ 5
- sample code available at
  - Problem 2
  - Problem 3
  - Problem 4
  - Problem 5
- Enjoy loop!!

Condition statement

- If statement

```
int i = 7;
if (i % 3 == 1) {
    cout << "Remainder : 1" << endl;
}
else if (i % 3 == 2) {
    cout << "Remainder : 2" << endl;
}
else {
    cout << "Remainder : 0" << endl;
}
```

- Quite Intuitive!!
  - If the condition of if statement returns true, executes its body
  - If not, goes to next statement (else if) and checks the condition
  - If the condition in else if statement returns true, executes its body
  - else, executes the body in else statement

Condition statement

- If statement
  - else / else if statement is not essential
  - you can only use if statement alone

```
int i = 1;
while(true) {
    cout << i << endl;
    i++;
    if(i > 3)
        break;
}

>> 1
   2
   3
```

loops forever until it reaches break statement

If i is bigger than 3, ends loop

Condition statement

- switch statement

```
switch(score) {
    case 10 :
        cout << "Your grade is A";    // executes when score == 10
        break;
    case 9  :
        cout << "Your grade is B";    // executes when score == 9
        break;
    case 8  :
        cout << "Your grade is C";    // executes when score == 8
        break;
    case 7  :
        cout << "Your grade is D";    // executes when score == 7
        break;
    default :
        cout << "Your grade is F";    // execute when score != 10, 9, 8, 7
}
```

  - If the value of variable `score` is 10, prints that the grade is 10

Condition statement

- Switch Statement

```
switch(score) {
    case 10 :
        cout << "Your grade is A";
        break;
    case 9  :
        cout << "Your grade is B";
        break;
    case 8  :
        cout << "Your grade is C";
        break;
    case 7  :
        cout << "Your grade is D";
        break;
    default :
        cout << "Your grade is F";
}
```

```
if (score == 10) {
    cout << “Your grade is A”;
}
else if (score == 9) {
    cout << “Your grade is B”;
}
else if (score == 8) {
    cout << “Your grade is C”;
}
else if (score == 7) {
    cout << “Your grade is D”;
}
else {
    cout << “Your grade is C”;
}
```

- two code block have same functionality!!
- sometimes using switch statement is more intuitive

Condition statement

- Switch Statement

```
switch(score) {
    case 10 :
        cout << "Your grade is A";
        break;
    case 9  :
        cout << "Your grade is B";
        break;
    default :
        cout << "Your grade is F";
}
```

  - Okay…why break??
  - Without break
    - switch statement just executes every case below selected case
    - i.e. slides down switch statement

Condition statement

- Switch Statement

```
score = 9
switch(score) {
    case 10 :
        cout << "Your grade is A” << endl;
    case 9  :
        cout << "Your grade is B” << endl;
    case 8  :
        cout << “Your grade is C” << endl;
    default :
        cout << "Your grade is F” << endl;
}


output >>
Your grade is B
Your grade is C
Your grade is F
```

```
score = 9
switch(score) {
    case 10 :
        cout << "Your grade is A” << endl;
        break;
    case 9  :
        cout << "Your grade is B” << endl;
        break;
    case 8  :
        cout << “Your grade is C” << endl;
        break;
    default :
        cout << "Your grade is F” << endl;
}

output >>
Your grade is B
```

- Never forget break!!

Programming!!

- Problem 6~10
- Sample Code Available at
  - Problem 6
  - Problem 7
  - Problem 8
  - Problem 9
  - Problem 10
- The famous “star-printing” example!!
  - Be creative!! every problem can be solved with only two for-statement
  - loop / condition statement is really powerful!!

Programming!!

- Problem 11 / Problem 12
- be familiar to loop / condition statement
- cf) switch statement:
  - less powerful than if statement, but sometimes enhances the readability of your code a lot
- Sample code available at
  - Problem 11
  - Problem 12

Functions

- Basic execution module of cpp
- not only for cpp, but also for every programming languages!!
- *A block of code which only runs when it called*
- *Able to pass data as parameters*
- *Able to return data (result) after the execution*

Functions

- Contents

```
int sum(int a, int b) {
    int result = a + b;
    return result;
}

int main() {
    cout << sum(3, 5) << endl;     >> 8
    return 0;
}
```

- Easy to use, just declare it, and use it!!
- Why useful??
  - easy to reuse code block
  - whenever you need to add two ints, you only need to call function sum

Functions

parameters, passed by the function which is calling this function
Data type / parameter name should be specified

function name

```
int sum (int a, int b) {
    int result = a + b;
    return result;
}
```

return type

returning result

result's data type should match to return type
in this case, variable `result` should be an int

if someone calls `sum(5, 8)`,
the function will calculate 5 + 8
and return the result (13)

Functions

- Just think as mathematical function!!
- $\sin(\cos\pi)$ can be interpreted as:
  - first, apply parameter π to function $\cos$.
  - again, apply the value returned from $\cos$ to function $\sin$.
  - then it will return final value.
- Same procedure can be adopted to the functions in cpp!!

```
float sin (float a) {
    ...return result;
}

float cos (float b) {
    ...return result;
}

int main() {
    cout << sin(cos(3.14)) << endl;
    return 0;
}
```

Functions

- Functions might have zero parameter, or return nothing
  - if no parameter

```
int returnsThree() {
    return 3;
}
```

  - if returns nothing

```
void printScore(int score) {
    cout << "Your score is: ";
    cout << score << endl;
    return;
}
```

    - use `void` to denote that the function returns nothing
    - just use `return` statement in alone (possible to omit)

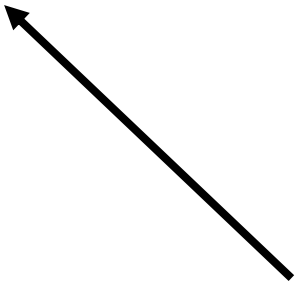
Programming!!

- Problem 13
- Sample code available at
  - https://github.com/jeonhyun97/cpp_4_undergraduates/blob/master/cpp/lecture0/code/13_arithmetic.cpp
- Enjoy function!!
- How about reimplementing problem 1~12 using function??

Recursion

- Powerful tool in computer science!!
- Achieves by implementing functions that calls themselves
- Let's see simple example…

```
int factorial(int n) {
    if (n == 1) return 1;
    else return factorial(n - 1) * n;
}

int main() {
    cout << "10! = " << endl;
    cout << factorial(10);
    return 0;
}
```



again calling itself

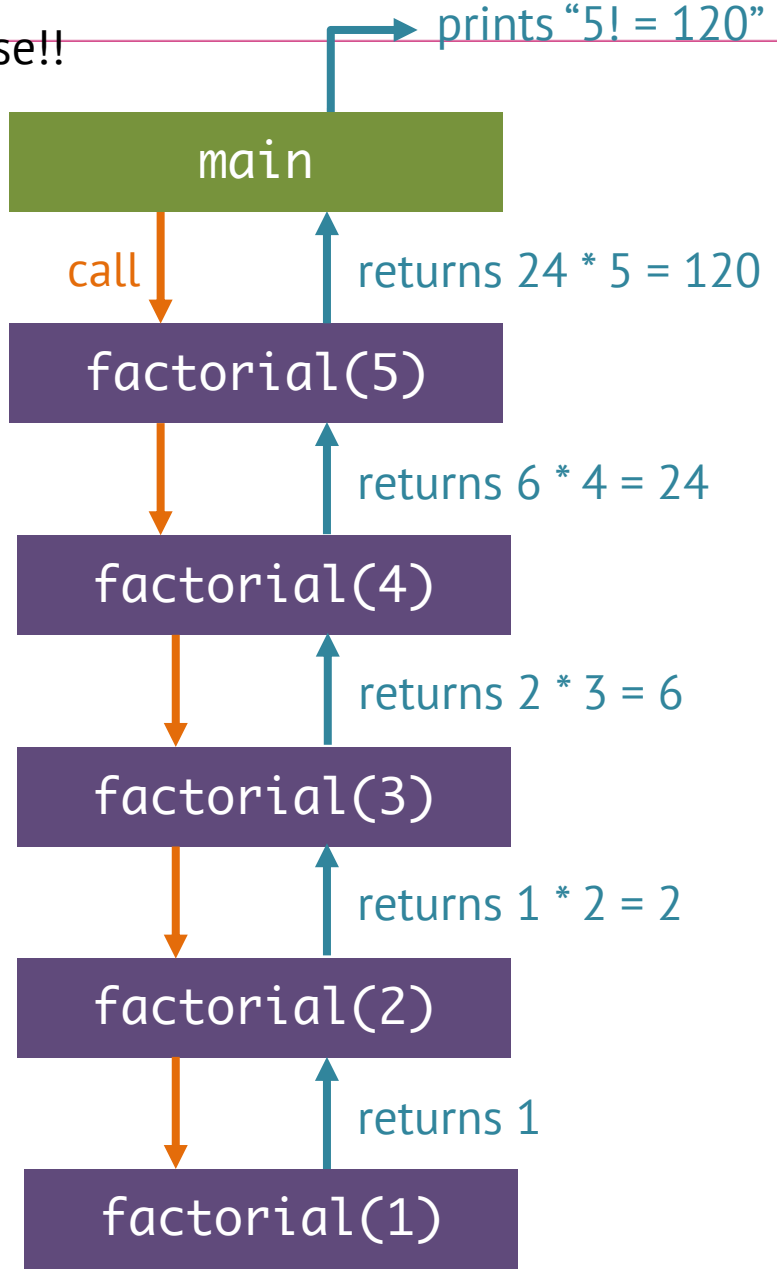
Recursion

try not to forget base case!!

- Let's analyze!!

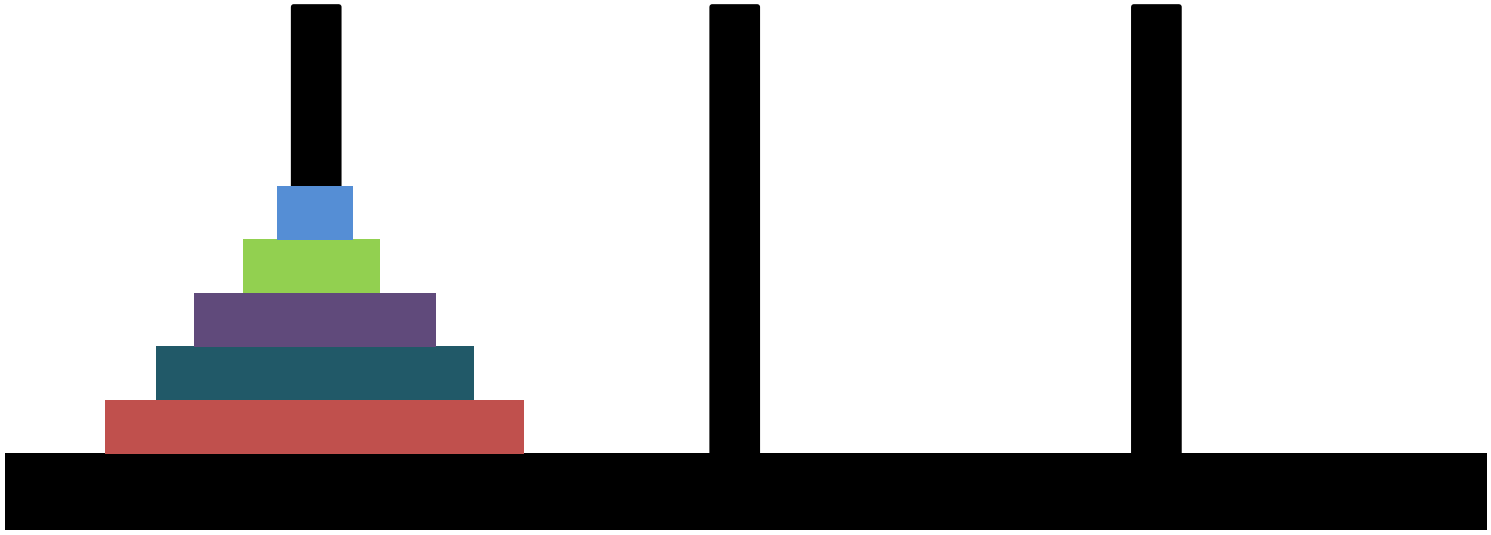
```
int factorial(int n) {
    if (n == 1) return 1;
    else return factorial(n - 1) * n;
}

int main() {
    cout << "5! = " << endl;
    cout << factorial(5);
    return 0;
}
```

- Generates Beautiful code!!



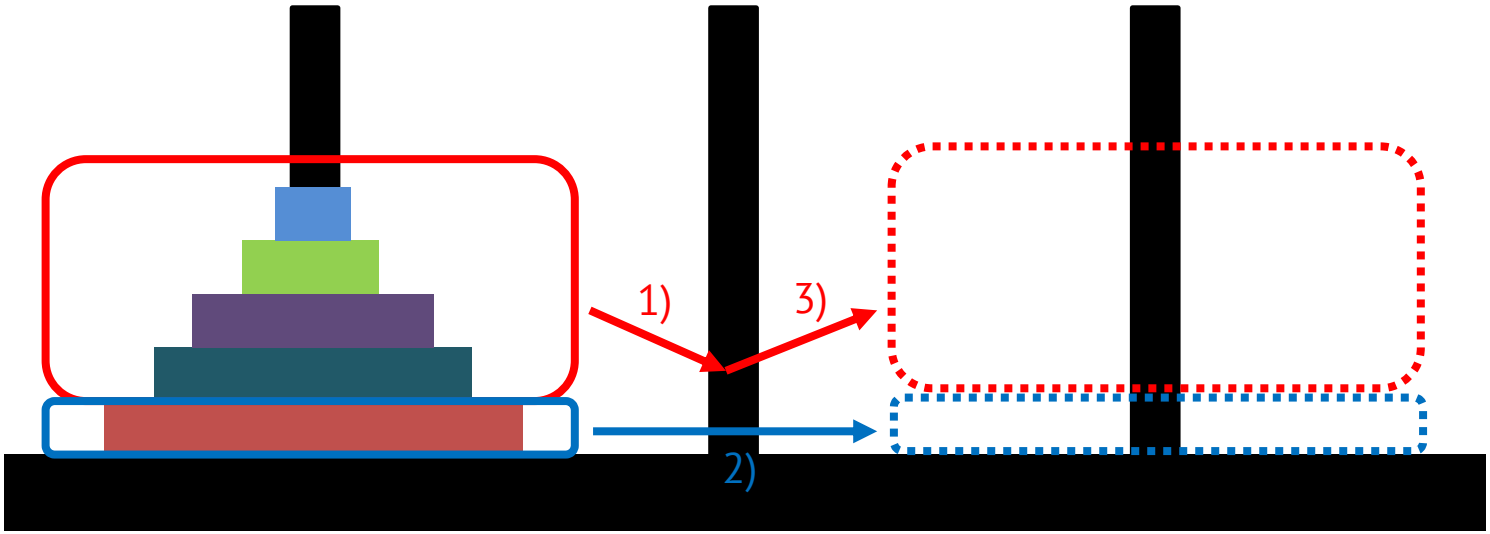
Recursion

- Famous example – Hanoi Tower problem
  - There exists 3 rods and 64 discs with varying size.
  - Monks should move every disc from one rod to other rod
  - However, larger disc cannot placed over smaller disc
  - How many times should the monks move the discs??



Recursion

- Hanoi Tower problem
- let's disassemble the procedure: moving n discs!!
  - Initially, every disc is in first rod
  - 1) move (n-1) discs to second rod
  - 2) move the largest disc to third rod
  - 3) move (n-1) discs to third rod



Recursion

- Hanoi tower problem
  - let's say (number of movements for n disc problem) : hanoi(n)
  - hanoi(n) = 2 * hanoi(n - 1) + 1
  - Now we can use recursion to solve problem!!


```
int hanoi(int n) {
    if (n == 1) return 1;
    else return (hanoi(n - 1) * 2 + 1);
}

int main() {
    cout << "Monks need to make ";
    cout << hanoi(10);
    cout << " movements to move 10 discs" << endl;
}
```

```
>> Monks need to make 1023 movements to move 10 discs
```

Programming!!

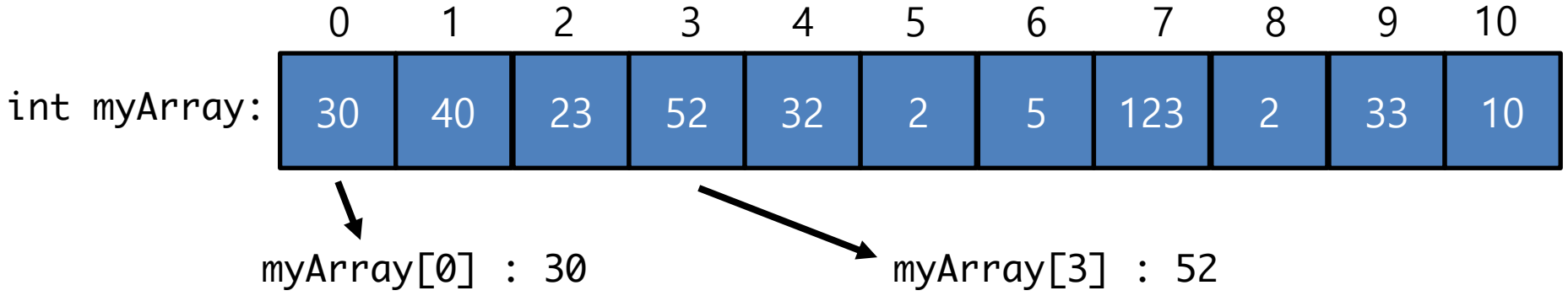
- Problem 14
- Sample code available at
  - https://github.com/jeonhyun97/cpp_4_undergraduates/blob/master/cpp/lecture0/code/14_fibonacci_easy.cpp
- Implement the program that calculates n-th Fibonacci number
- use recursion!!
- Fibo(n) = Fibo(n-1) + Fibo(n-2)
- hint : base case
  - Fibo(1) = 1, Fibo(2) = 1

Array

- Basic container to store data
- easy data assignment / access using index
- Think of storing the score of 30 students
- declaring variable `student1, student2...student30...???`
- Inefficient!!
- how about just declaring array:
  - `int student[30]`
  - and access the score of i-th student using `student[i]`??

Array

- Any data type can construct array!!
  - `int myArray[30];`
  - `float myArray[30];`
  - `string myArray[30];`
- Index starts with 0 (zero)
  - less intuitive, but one of the most important feature in CS field



Array

- Various ways to initiate value

```
int x[] = {1,2,3}; // x has type int[3] and holds 1,2,3
int y[5] = {1,2,3}; // y has type int[5] and holds 1,2,3,0,0
int z[5] = {1,2,3,4,5}; // z has type int[5] and holds 1,2,3,4,5
int w[3] = {0}; // z has type int[3] and holds 0,0,0
```

- Or just use burdensome method

```
int x[3];
x[0] = 1;
x[1] = 2;
x[2] = 3; // x has type int[3] and holds 1,2,3
```

Array

- Simple example will help you…

```
cout << myArray[0] << endl;      >> c
cout << myArray[1] << endl;      >> cpp
cout << myArray[2] << endl;      >> java
myArray[1] = "c++";
cout << myArray[1] << endl;      >> c++
```

- cf) iterate array:

```
for(int i = 0; i < 3; i++) {
    cout << myArray[i] << endl;
}
```

```
Output:
c
c++
java
```

Multi-dimensional array

- sometimes, you want to represent data in 2D
- ex) matrix
  - $\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$: better to represent it with 2D array!!
  - `matrix[2][2] = {{1, 2}, {3, 4}}`
  - `=> matrix[0][1] : 2`
  - `=> matrix[1][0] : 3`
- iterating 2D array : use double for-statement!!

```
for(int i = 0; i < 2; i++) {
    for(int j = 0; j < 2; j++) {
        cout << matrix[i][j] << " " << endl;
    }
    cout << endl;
}
```

```
>> 1 2
   3 4
```

Programming!!

- Problem 15
- Efficient way to achieve n-th Fibonacci number
- Sample code available at
  - https://github.com/jeonhyun97/cpp_4_undergraduates/blob/master/cpp/lecture0/code/15_fibonacci_normal.cpp
- use array holding Fibonacci series!!
- Fibo[0] = 1, Fibo[1] = 1, Fibo[2] = 2 … Fibo[n-1] = (n-th Fibo num)

Programming

- Problem 16
  - Sample code
- Much more efficient way for Fibonacci num!!
- hint: use the formula :
- $\begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix}^n = \begin{pmatrix} F_{n+1} & F_n \\ F_n & F_n \end{pmatrix}$ and therefore
- $\begin{pmatrix} F_{n+1} & F_n \\ F_n & F_n \end{pmatrix} = \begin{pmatrix} F_{k+1} & F_k \\ F_k & F_{k-1} \end{pmatrix}^2$ if n is even number $(\mathrm{k} = \frac{n}{2})$
- $\begin{pmatrix} F_{n+1} & F_n \\ F_n & F_n \end{pmatrix} = \begin{pmatrix} F_{k+1} & F_k \\ F_k & F_{k-1} \end{pmatrix} \begin{pmatrix} F_k & F_{k-1} \\ F_{k-1} & F_{k-2} \end{pmatrix}$ if n is odd number $(\mathrm{k} = \frac{n+1}{2})$
- Implement the function which multiplies matrix!!
- Maybe you might be surprised by `int**` syntax
- From now, just use it!!

Programming!!

- Problem 17
- Final problem to learn the prerequisites for this course!!
- Implement bubble sort!!
- Material: https://www.programiz.com/dsa/bubble-sort
- Korean: https://gmlwjd9405.github.io/2018/05/06/algorithm-bubble-sort.html
- Try not to reference code!!
- Sample code available at
  - https://github.com/jeonhyun97/cpp_4_undergraduates/blob/master/cpp/lecture0/code/17_bubbleSort.cpp

Thank you!!

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