→ more important note and Week Lecture / homework

→ Data Structure

→ links

→ Heading

Every week from new page

→ Subheading or important point

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Bhaiya Bday
20 June 1998
7:15 AM

IMPORTANT POINTS

- Focus on work on skill and build networks those work in companies and can talk to HR for you
- Internship- do if you want to learn or convert it as PPO
- Rough sols. and dry run are very important
- Do documentation to promote and mail everything you dismss with HR or team
- Think twice, Code once
- To clarify any code you are confused, use cout statements every where to know what is going on in the code
- Code all approaches you can think of and can find & understand from google
- Revise all incorrect & skipped questions in quizes regularly
- Watch sol. only after attempting the question
- Interviewer will ask Time & Space complexity after every sol. you give

- 2 websites
  - cppreference
  - cplusplus.com

IMPORTANT C++ NOTES

→ Making global variable is BAD PRACTICE

→ To increase range of int / long long ,
you can use unsigned int / long long

→ % → heavy operator
↳ so try to use it less
Use bitwise operators instead of this if possible

→ arr[n] ⟶ BAD PRACTICE
arr[100000] is better than arr[n]

→ to find min., start ans from INT_MAX

→ to find max, start ans from INT_MIN

→ n & 1 gives rightmost bit of n

→ xor → cancels out same elements

0 ^ ans = 0 → 0^1 = 1
→ 0^0 = 0

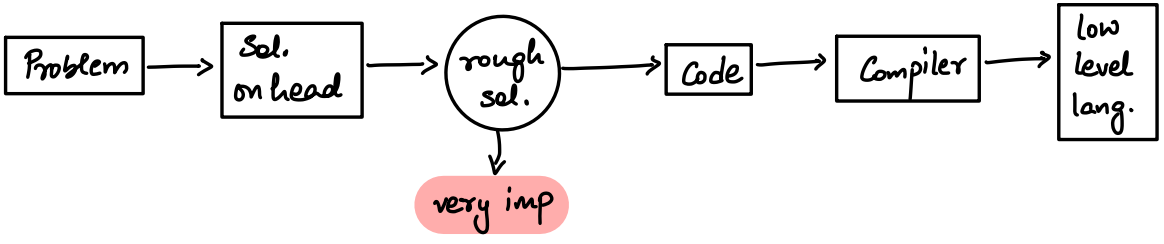
W1-L1

Thought process to solve a problem-

→ Understand a problem

→ input values

→ find approach

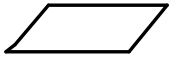


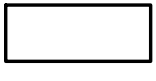
Algorithm- Sequence of steps

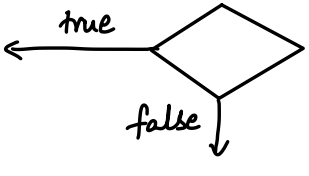
Flowchart- Graphical representation of algo

Components-

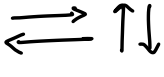

terminator for start /end

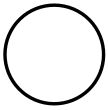

for input /output read /write


computation / process / declaration



decision making block takes condition


flow



Connector

takes function

Pseudo Code- Generic way of writing algo

Dry Run → Very important to understand any topic

W1-L2

IDE- Replit, VS-Code

```
# include <iostream>
using namespace std;
int main (){
    cout << "Namaste Bharat";
}
```

preheader file contains implementation of identifiers

using standard namespace implementation of cout choosing from multiple types of namespace

region where scope of identifier is defined

to end any statement

string

used to print on console/ standard display

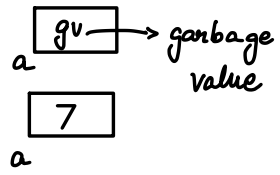
cout << endl; → for next line

cout << '\n';

int a ; ⟶ a is an integer

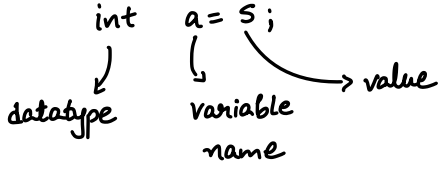
cin >> a ; ⟶ input a from user

ex-7



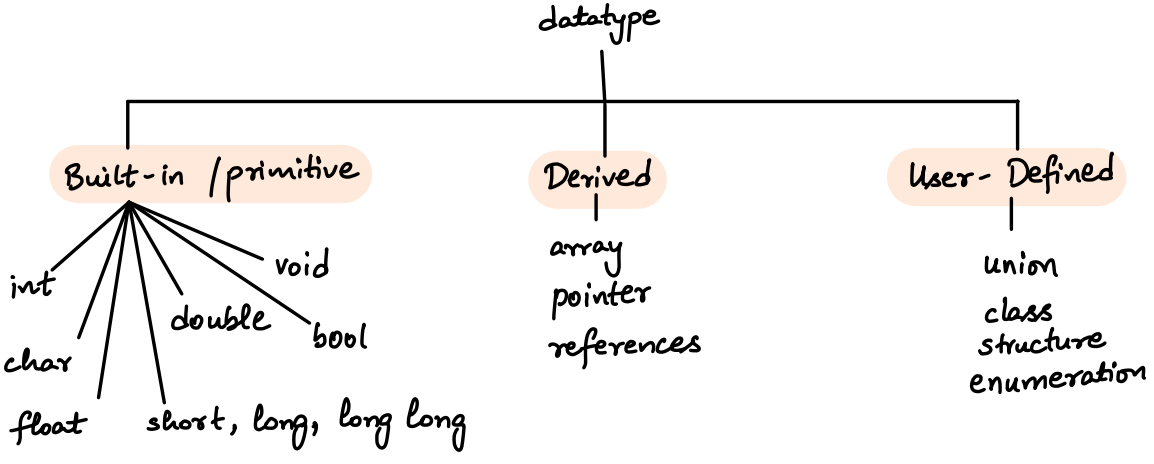
Variables

named memory location



Datatypes

type of data



int - 4 byte - 32 bits in memory

- → -2^{31} to $2^{31}-1$ in signed int
- → 0 to $2^{32}-1$ in unsigned int

char - 1 byte - 8 bits in memory

- → 2^8 different chars.

ASCII
↳ char maps with numerical ASCII value

char ⟷ ASCII value ⟶ store in memory

bool → 1 byte → 8 bits

true - 1
false - 0

↳ because minimum addressable memory is 1 byte
We cannot address 1 bit in memory

float → 4 byte → 32 bits

double → 8 byte → 64 bits

long long → 8 byte → 64 bits

short → 2 byte → 16 bits

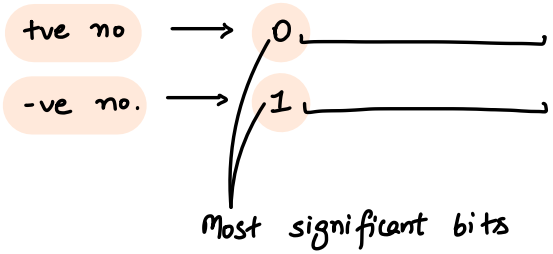
long → 4 byte → 32 bits

How data is stored

```
int a = 5;
```

↳ 32 bits 0...00101

29 bits



How -ve number is stored in memory

In 2's complement form

→ 1's complement + 1

→ reverse all bits

int a = -7;

7 → 0.....00111 } 32 bits

ignore -ve sign

find binary equivalant

1's (7) → 1.....11000

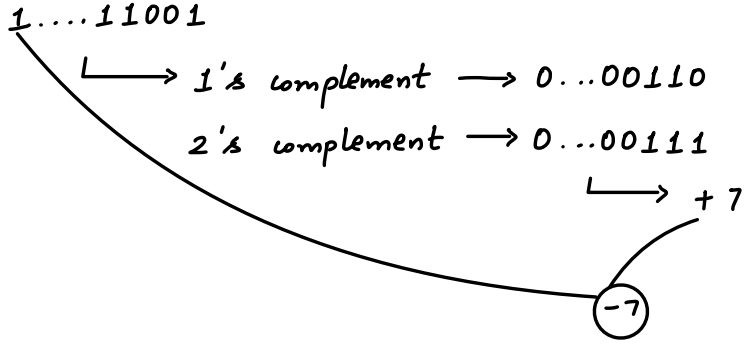
find 2's complement

2's (7) → 1.....11001

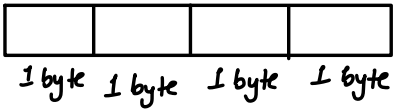
→ this is how -7 will be stored in memory

How to read -ve no. present in memory

→ take 2's complement



Interesting problem



how computer know these are 4 chars or a single integer

- Using datatype
  - tell 2 things
    - type of data used
    - space used in memory

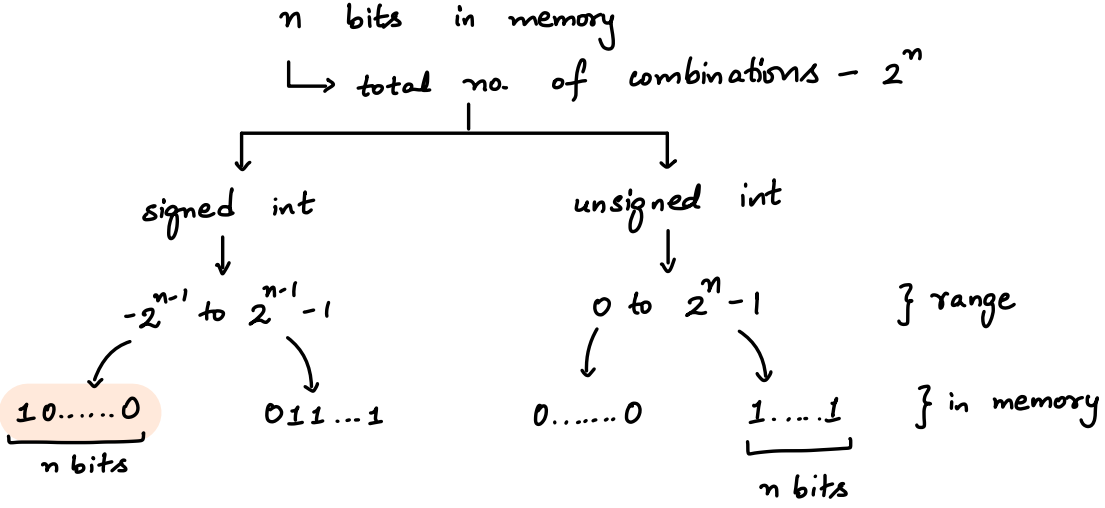
Signed vs Unsigned

- Unsigned → 0, +ve
- Signed → +ve, -ve, 0
  - by default

int - 4 byte - 32 bits in memory

- total no. of combinations - 2^{32}
  - signed int
    - -2^{31} to $2^{31}-1$ } range
      - 1 0...0
      - 0 1 1 ... 1 } in memory
      - 2's → 1 0...0 → -2^{31}
  - unsigned int
    - 0 to $2^{32}-1$ } range
      - 0.....0
      - 1....1 } in memory

General Formula



Typecasting

↳ convert one type of data to another

implicit typecasting

```
ex- char ch= 97;
    cout << ch;
```
⟶ (a)

explicit typecasting

```
ex- char ch = (char) 97;
    cout << ch;
```
⟶ (a)

overflow ex-

```
char ch = 9999;
cout<< ch;
```

9999 ⟶ (binary conversion) 100 111 0000 1111

stores only last 8 bits

so ch stores 00001111 in memory

↓

7

↓

acc. to ASCII table

Operators -

Arithmatic Operator

↳ +, -, *, /, %,

int op int ⟶ int

float op int
int op float
float op float
} ⟶ float

double op int
int op double
double op double
float op double
double op float
} ⟶ double

bool op bool ⟶ int

bool act as 0 or 1

3 → int
3.0 → float / double ⟶ by default ⟶ cout << sizeof(3.0);

not int

↓

8

Relational Operator

a op b

>, <, >=, <=, !=, ==

these are different things

Output – 0 or 1

false ↙ ↳ true

Assignment Operators

=

Logical Operators

↳ when you have multiple conditions

a && b ⟶ and ⟶ true if both are true

a || b ⟶ or ⟶ true if any one is true

! a ⟶ not ⟶ negate the result

Output - 0 or 1

false ↙ ↘ true

(cond 1 && cond 2 && cond 3)

if cond 1 is false

compiler will not check further as ans will already false

(cond 1 || cond 2 || cond 3)

if cond 1 is true

compiler will not check further as ans will already true

Conditions

W1-L3

```
if (cond.){
    execute
}
```

if

```
if( cond ){
    execute 1
}
else {
    execute 2
}
```

if - else

```
if (cond 1)
    execute 1
else if( cond 2)
    execute 2
```

if - else if

```
if (cond 1)
    execute 1
else if ( cond 2)
    execute 2
else if (...
else
    execute n
```

if - else if - else

```
if (cond 1)
    execute 1
else {
    if ( ) { }
    else ( ) { }
}
```

nested if - else

Loops

↳ to do something repeatedly

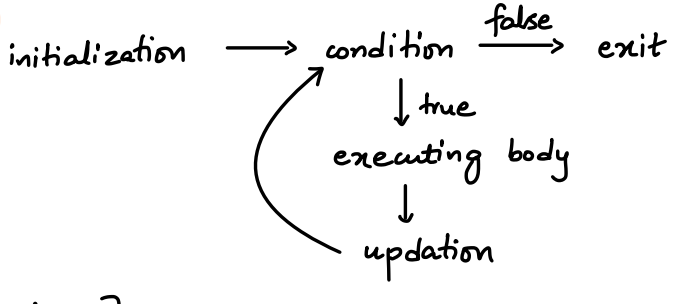
for - loop

initialization, condition, updation

```
for ( int i=0 ; i<5 ; i=i+1 ) {
    cout << "Love" ;
}
```

→ executing body

flow -



initialization
condition
updation

} none is mandatory
one or multiple i, c, u can be added

multiple c → i>5, i<10; → i>5 && i<10

patterns -

Generally 2 loops ⟶

```
outer loop(){          → for rows
    inner loop(){      → for cols
    }
    cout << endl;
}
```

→ a op= b ⟶ a = a op b

op ⟶ +, -, *, %, /

cin in if( )

```
int num;
if(cin >> num){
    cout << "hello";
}
else{
    cout << "hi";
}
```

it will not give error

output -

hello

for all values of num ↓

0, +ve, -ve

cout in if( )

```
int num = 0;
if(cout << num << endl){
    cout << "hello";
}
else{
    cout << "hi";
}
```

it will not give error

output -

0

hello

for all values of num ↓

0, +ve, -ve

HLL - High level language

↳ human readable and user friendly

W1-L4

C++, C - Middle Level language

namespace ⟶ to avoid collision

↓

multiple definitions of a single keyword

heirarchy

↳ various namespaces

↓

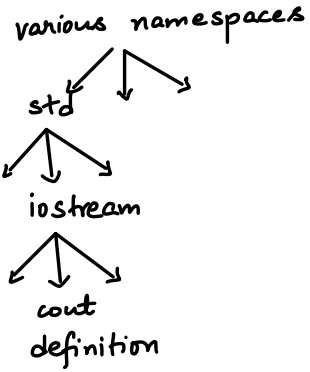
std namespace

↓

iostream preheader file

↓

keyword definition




```
float f = 2.0 + 100;
cout << f;
```

⟶ output -

102 or 102.0

compiler dependent

```
float f = 2.7;
int n = 157;
int diff = n-f;
cout << diff;
```

output -

154

explanation -

n-f = 157 - 2.7 = 154.3

int diff = n-f

diff = 154

ternary operator -

↳ syntax

W1-HW

variable = (condition) ? expression2 : expression3

(condition)? variable = expression2 : variable = expression3

by default -

cout << sizeof (2.3); ⟶ 8

↳ ⟶ float

cout << sizeof (a); ⟶ 4 ⟶ int

↳ ⟶ $-(2^{31}-1)$ to $2^{31}-1$

cout << sizeof (-2^{31}) ⟶ 8

↳ ⟶ long long

patterns

W2-L1

↳ how to think

→ finding formula for rows and cols

n=5

row	stars
0	0
1	0
2	1
3	2
4	3

→ formula- 0 to < n-1

n-1
-1
0
1
2
3

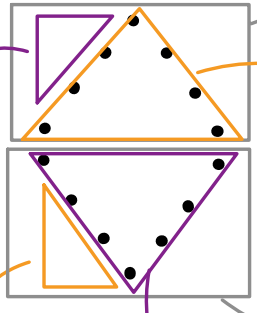
no. of times loop runs
0
0
1
2
3

→ as condition fails (0<-1)

→ to do anything n times

↳ for(i=0 ; i<n; i++){}

→ break the complex patterns



upper half

0 to < 2i+1

chars	
0 → 1	1
1 → 3	2(1)+1
2 → 5	2(2)+1
3 → 7	2(3)+1

0 to < n-(i+1)

space	
0 → 3	4-1
1 → 2	4-2
2 → 1	4-3
3 → 0	4-4

lower half

0 to < i

space	
0 → 0	i
1 → 1	i
2 → 2	i
3 → 3	i

0 to < 2n-2i+1

chars		
0 → 7	8-1	8-1
1 → 5	8-3	8-(2(1)+1)
2 → 3	8-5	8-(2(2)+1)
3 → 1	8-7	8-(2(3)+1)

W2-L2

Bitwise Operators

↳ use on bit level

And	(a & b)	1 if both bits are 1
Or	(a | b)	1 if any or both bits are 1
not	(~ a)	negate the result
xor	(a ^ b)	same values → 0 diff. values → 1

~5

↳ 5 → 0...0101

~5 → 1...1010

↳ how compiler read this

↳ 2's complement

0....0101 → 1's complement

0...0110 → 2's complement

-6

So ~5 = -6

Left and right shift operators

<<

shift all bits to left

* by 2 (not in every case)

↳ if MSB is 1 and 2nd MSB is 0

>>

shift all bits to right

/ by 2 (not in every case)

↳ in -1

a = a << b a left shifts, b times → result → $a \times 2^b$

a = a >> b a right shifts, b times → result → $\frac{a}{2^b}$

b cant be -ve

↳ in case of -ve

↳ gives gv

```
a = 5;
a = a << 1;      a = 10

a = 5;
a = a << 2;      a = 20
```

in left shift → filled with 0

in right shift → filled with 0 and 1

in +ve no. ← 0 and 1 → in -ve no.

right shift in -ve number

-ve no. in memory → 1 .....

↓ right shift

11....

↳ signed bit is used to fill the vacant bit

ex-

5 → 0...0 101

-5 → 1...1 011

-5 >>1 → 1...101 → -3

-1 >> 1 → -1

left shift in number where MSB is 1 and 2nd MSB is 0

no. → 10. . → -ve no.

left shift ↳ 0....

↳ +ve no.

Pre- Post → Increament / Decreament Operator

pre- increament
↳ ++a
↳ first increament by 1, then use

post - increament
↳ a++
↳ first use then increament by 1

pre- decreament
↳ --a
↳ first decreament by 1, then use

post - decreament
↳ a--
↳ first use then decreament by 1

```
int a= 5;
cout << (++a) * (++a) ;
```

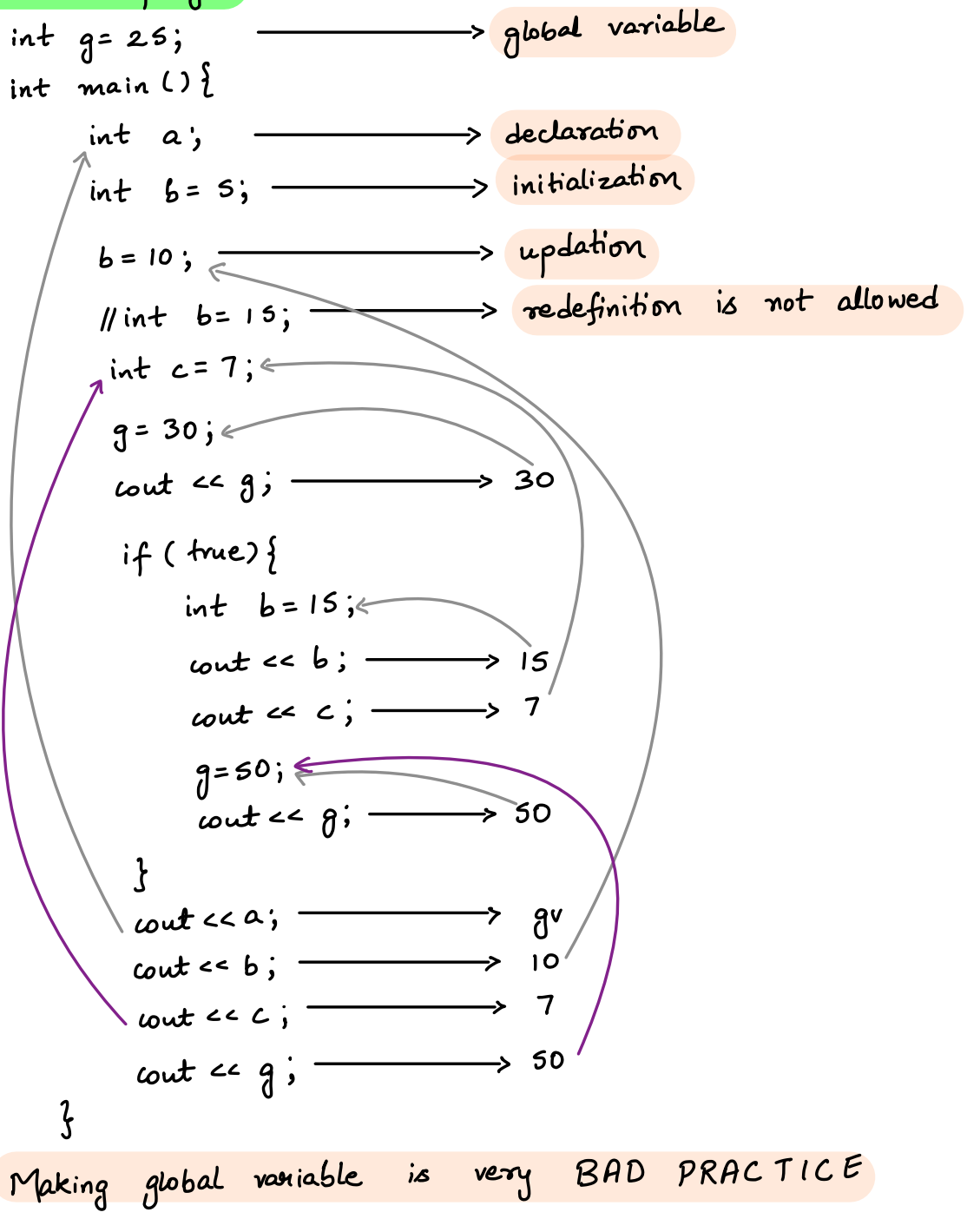
output -
49
↳ due to operator precendence

break and continue

break
↳ exit from that loop

continue
↳ skip that iteration

Variable Scoping -



Making global variable is very BAD PRACTICE

Operator Precedence

- order of priority of operator
- no need to remember
  - use brackets properly

Switch Case

can also have nested switch case

```
switch (expression) {

    case value1 :
        executing body 1
        break;
    case value2 :
        executing body 2
        break;
    :
    case value n :
        executing body n
        break;

    default :
        executing body
}
```

not mandatory

without break
- all below executing body will also execute

→ continue cannot be used in switch case
- can only use in loops

W2-L3

Function -

- program linked with well defined task
- why
  - reusable
  - readable
- without
  - bulky
  - lengthy
  - buggy if mistake in any place

syntax -

```
return type functionname ( input parameters) {
        function executing body
}
```

void → empty / no value

```
int main(){
    return 0;
}
```

return 0; → returns 0 to Operating System

0 is used as means of successful execution

→ a cpp file cant have more than 1 main functions

Function Call Stack

function call ⟷ function invoke

Stack
- Last In First Out

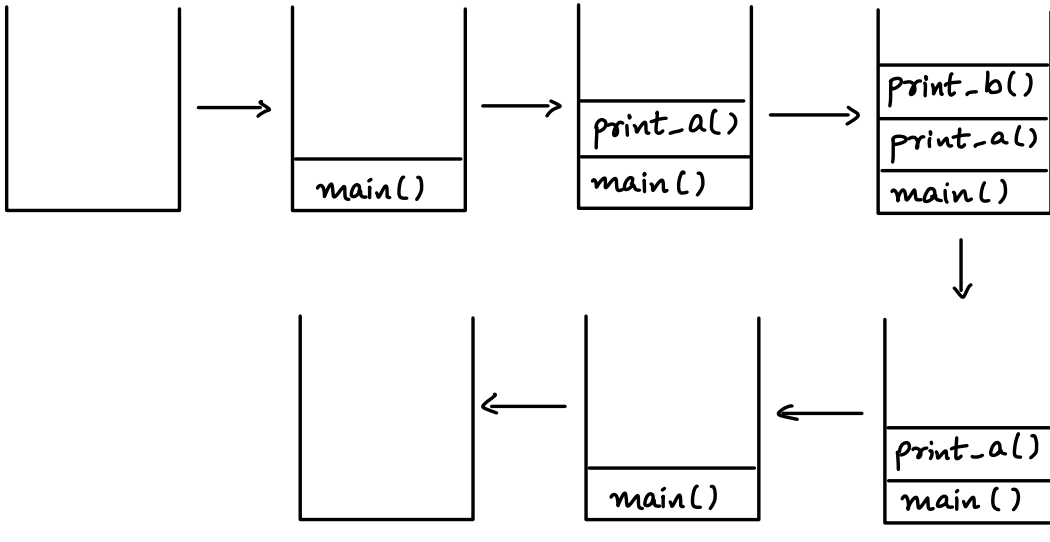
tells
- what functions
- which function calls which
- local variables of function
- return type of function

ex-

```
int main(){
    int a=5;
    print_a(a)
    return 0;
}

void print_a(int a){
    cout<< a;
    int b=3;
    print_b(b);
}

void print_b(int b)
{
    cout<< b;
}
```



Pass by value

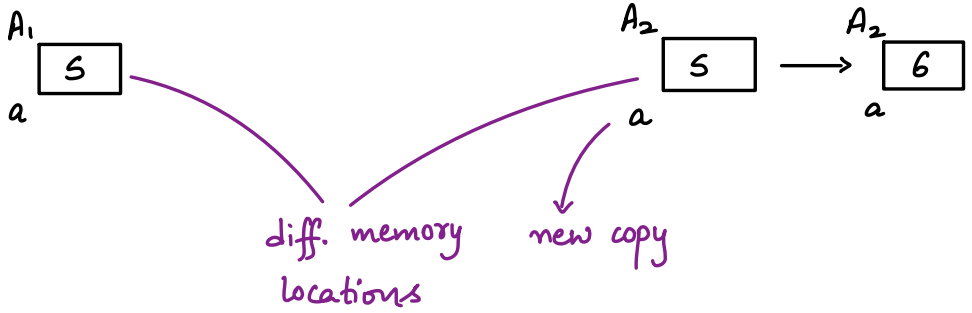
↳ a copy will be created of variables

```
int main() {
    int a = 5;
    printNumber(a);
    cout << a;
}
```

argument

```
void printNumber(int a){
    cout << a;
    a++;
    cout << a;
}
```

parameter



Address Of Operator &

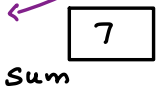
```
int n = 5;
cout << &n;
```

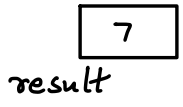
⟶ output - address of n

```
int main(){
    int a = 2;
    int b = 3;
    int sum = add(a, b);
    cout << sum;
    return 0;
}
```

OS

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





Function Order

Order 1

```
int add (int a, int b) {
    return a+b;
}
int main () {
    int a= 3;
    int b = 5;
    int sum= add (a, b);
    cout << sum;
    return 0;
}
```

function declaration and definition

Order 2

function declaration

```
int add (int a , int b);
int main () {
    int a= 3;
    int b = 5;
    int sum= add (a, b)
    cout << sum;
    return 0;
}
int add (int a, int b) {
    return a+b;
}
```

function definition

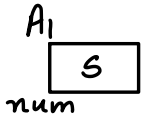
% operator ⟶ heavy operator

↳ so try to use it less

W2-L4

BTS → Behind The Scenes

```
int num=5;
```



Symbol table

int num ⟷ A_1

- int → datatype
- num → variable name
- A_1 → variable memory location
- variable mapping with address is stored

```
cout <<num;
```

go to → symbol table → go to → A_1 (address) → print → 5 (value)

while loop

```
int i=0;                    → initialization
while (i<5) {               → condition
    cout<< i <<endl;        } → body
    i++;                    → updatation
}
```

flow

initialization → condition → false → exit

condition → true → body (containing updatation) → condition

left and right shift operators

```
int a= 2;
a<<1 ;  ------------------> no change
cout<< a;  ---------------> 2
a= a<<1;  ----------------> change ---> left shift by 1
cout <<a;  ---------------> 4
```

right shift in -ve no.

↳ link in links.txt in repo

Number System

- method to represent numeric values using digits

Decimal Number System

- base 10
  - digits → 0 to 9

Binary Number System

- base 2
  - digits → 0, 1
- used in CPU, memory, computer
  - 0 → power off
  - 1 → power on
  - number, images, all files & folder are in binary

Decimal to Binary

- divide no. by 2
- store remainder
- repeat above steps until no. is 0 or 1
- reverse the bits so obtained

Binary to Decimal

- multiply each bit with its place value
  - base ^{i}
    - 2^{i}
- add all products

Time & Space Complexity

Time Complexity

- amount of time taken by an algo as a function of length of input
- not actual time
- it defines CPU operations
- use case -
  - to make efficient programs
  - ask by interviewer after every sol. you give

Space Complexity

- amount of space taken by an algo as a function of length of input

Units to represent Complexity

Big O ⟶ upper bound ⟶ worst case

Theta Θ ⟶ average case

Omega Ω ⟶ lower bound ⟶ best case

Big O Complexities

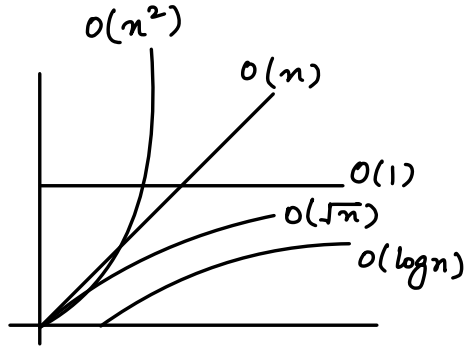
$O(1)$ ⟶ Constant time

$O(n)$ ⟶ Linear time

$O(\log_2 n)$ ⟶ Logarithmic time

$O(n^2)$ ⟶ Quadratic time

$O(n^3)$ ⟶ Cubic time



nesting ⟶ multiply ⟶

```
{
  { }
}
```

in sequence ⟶ add

```
{ }
{ }
```

$$f(n) = 4n^4 + \frac{n^3}{5} + \log n + n\log n \longrightarrow O(n^4)$$

Complexity Order

$$O(1) < O(\log_2 n) < O(\sqrt{n}) < O(n) < O(n\log_2 n) < O(n^2)$$

$$< O(n^3) < O(2^n) < O(n!) < O(n^n)$$

ARRAY

W3-L1

- Data Structure to store similar items
  - same datatype
- Continuous memory location space
- use case
  - for multiple huge same kind of data

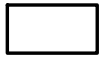
int a[30000]; ⟶ 30000 variables are ready

continuous memory location

- memory wastage
  - if needable memory is present but not in continuous way

int a = 5;

A



a

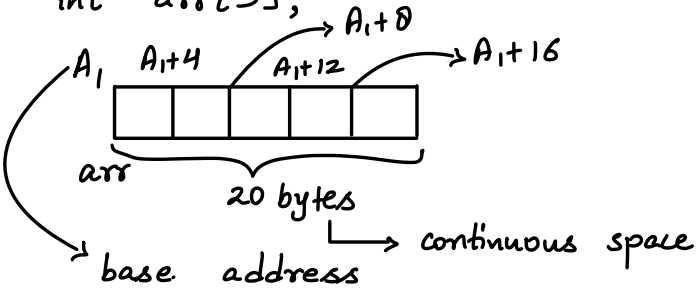
symbol table

int a ⟷ A

int arr ⟷ A_1

Declaration

int arr[5];



`cout << arr ;` ⟶ A_1

`cout << &arr ;` ⟶ A_1

Initialization

```
int arr[] = {2,4,6,8,10}
int arr2[5] = {2,4,6,8,10}
int arr3[10] = {2,4,6,8,10}
int arr4[4] = {2,4,6,8,10};
int arr5[10] = {0};
```

`arr3` ⟶ remaining 5 will be 0

`arr4` ⟶ ERROR

`arr5` ⟶ initializing all values with 0

Making array at runtime

```
int n;
cin >> n;
int arr[n];
```

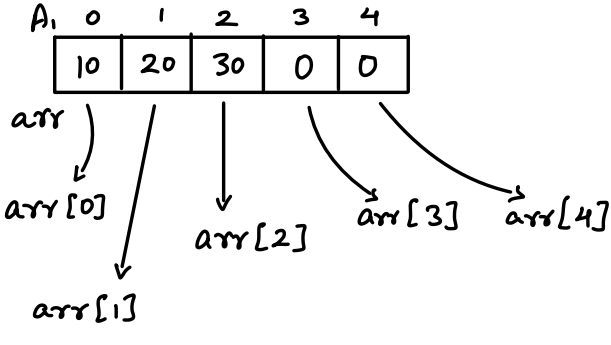
⟶ BAD PRACTICE

Index and Access in memory

```
int arr[5] = {10, 20, 30};
```

⟶ 0^{th} based indexing

↳ 0 to n-1



arr[i] ⟶ value at address [arr + (i*4)]

- arr → A_1
- i → index
- 4 → due to int (datatype size)
- 0 → thats why 0 based indexing

taking input in array

```
cin >> arr[i];
```

Arrays and Function

```
func ( int arr[], int size) {
}
```

- pass by reference
- updation in actual array
- always pass size alongwith arr

```
int main() {
    int arr[] = {5, 6};
    int size = 2;
    func (arr, size);
    return 0;
}
```

```
void func ( int a[], int size){
    a[0] = a[0] +10;
}
```

5 is	6

arr

sizeof(int); ⟶ 4 ⟶ in bytes

int arr[5];

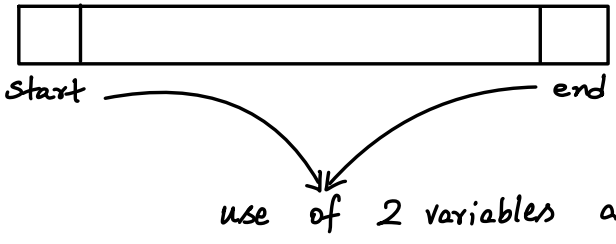
sizeof(arr); ⟶ 20 ⟶ in bytes

linear search in array

INT_MIN and INT_MAX

- ⟶ to find max., start ans with INT_MIN
- ⟶ to find min., start ans with INT_MAX

2 pointer approach



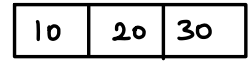
use of 2 variables as extreme points

Vector

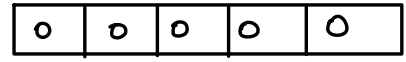
- Data structure
- Same as array but dynamic
  - size not fixed
- default size → 0
- if gets full and new items are inserted
  size gets doubled

Initialization

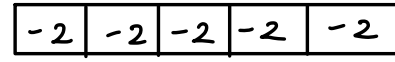
```
vector <int> arr {10,20,30};
```




```
vector <int> arr (5);
```




```
vector <int> arr (5, -2);
```

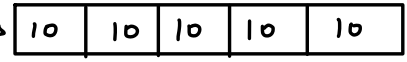



```
int n;
cin >> n;
```

let n = 5

```
vector <int> arr(n);
```


```
vector <int> arr (n, 10);
```



Insertion -

```
arr.push_back (5);
```

Remove

```
arr.pop_back ();
```

Size -

```
arr.size ();
```

→ no. of elements it stores

declaration

```
vector <int> arr;
```

- arr.size() → 0
- arr.capacity() → 0

Empty or Not

```
arr.empty();
```

Capacity -

```
arr.capacity();
```

→ * by 2 if arr gets fully filled and a new element is inserted

→ no. of elements it can store

→ in initialization, capacity = size in all methods

sizeof(arr);

→ compiler dependent initially

```
cout << arr ;
```

→ give ERROR

→ Xor → Cancels out same element

0 ^ ans = ans

→ 0 ^ 1 = 1

→ 0 ^ 0 = 0

for each loop

```
for (auto val: arr){
    cout << val << ' ';
}
```