→ more important note and Week Lecture / homework / recording

→ Data Structure

→ links

→ Heading

Every week from new page

→ Subheading or important point

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https://github.com/Ujjwal2327/DSA-SUPREME

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
- Think on paper
- Write readable codes
- In interviews, tell approaches of questions using example
- Signs of beginner → no logic build
  - cant solve new ques
  - forget the approach
  - memorizing the ans

  ↓

  Improve → with more no. of questions
  - with time
  - with dry run on mind logic, not on code
  - with your new approach (even brute force)
  - with a lot of practice on syntax
  - with consistency

→ Focus on placement, not on feeling

You are not studing to get fun

You are studing to get placement

First placement, then fun and interest.

Also focus on health of you and your parents

Bhaad me gya interest yaar, placement ke baad krna

Jo duniya sunna chahati hai, use sunado

Growth is important

Week 4 [Connect] Class 1:45 - 2:01

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

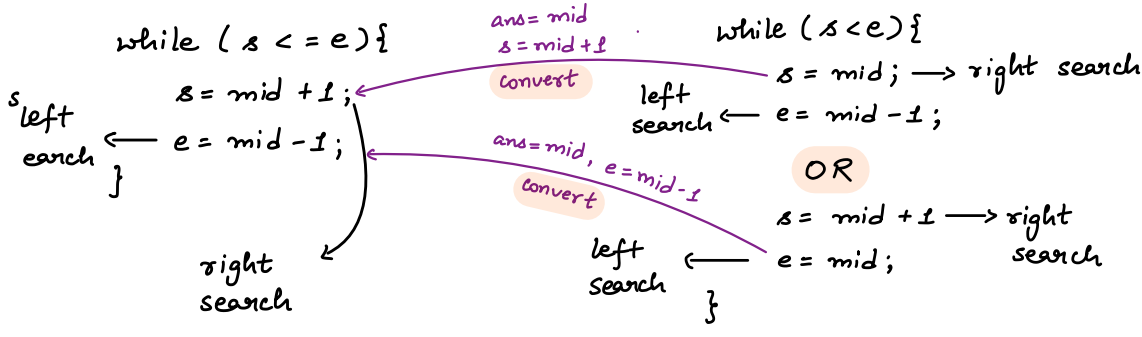
  arr[100000] is better than arr[n]
- to find min., start ans from INT_MAX
- to find max, start ans from INT_MIN
- n & 1 gives rightmost bit of n
- xor → cancels out same elements

  0 ^ ans = 0
  - → 0^1 = 1
  - → 0^0 = 0
- In ASCII ⟶ '0' ⟶ 48
  - 'A' ⟶ 65
  - 'a' ⟶ 97

→ Search Space

- → find range of search space (start & end) in ques of. Binary Search Questions
- → store mid in ans if needed

→ In binary search questions



→ Types of ques in binary search

- → 1st type → classic questions
- → 2nd type → find in search space (range)
  - → predicate function
    - logic to decide either left or right
- → 3rd type → observation in index

→ In sorted array, try to apply binary search or 2 pointer / 3pointer approach

→ To maximize or minimize
try to use binary search using concept of search space

- → find search space of answer
- → find mid
- → if isPossibleAns(mid) → go to left / right acc. to the ques.

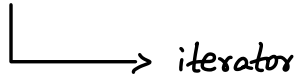
STL ALGORITHMS

binary search in array

```
bool ans = binary_search ( arr, arr + size, target );
```

lower bound in array

```
auto ans = lower_bound ( arr, arr + size, target );
```



upper bound in array

```
auto ans = upper_bound ( arr, arr + size, target );
```

binary search in vector

```
bool ans = binary_search ( arr. begin (), arr. end (), target);
```

lower bound in vector

```
auto ans = lower_bound ( arr. begin (), arr. end (), target);
```

upper bound in vector

```
auto ans = upper_bound ( arr. begin (), arr. end (), target);
```

INBUILT FUNCTIONS OF STRINGS

length

```
str. length();
```

empty or not

```
str. empty();  ⟶ 1 if empty, otherwise 0
```

push back

```
str. push_back('char');
```

pop_back

```
str. pop_back();
```

substring

```
ans = str. substr( starting index, no. of chars);
```

compare

```
str. compare(str2);
```

- → 0 if equal
- → +ve if str[i] > str2[i]
  - first diff. chars
- → -ve if str[i] < str2[i]

find

```
str.find(str2);
```

→ starting index if found

→ string::npos if not found

string::npos

highest possible value

replace

```
str.replace(starting index, no. of chars, str2);
```

erase

```
str.erase(starting index, no. of chars);
```

insert

```
str.insert(starting index, str2);
```

string to int

```
int ans = stoi(str);
```

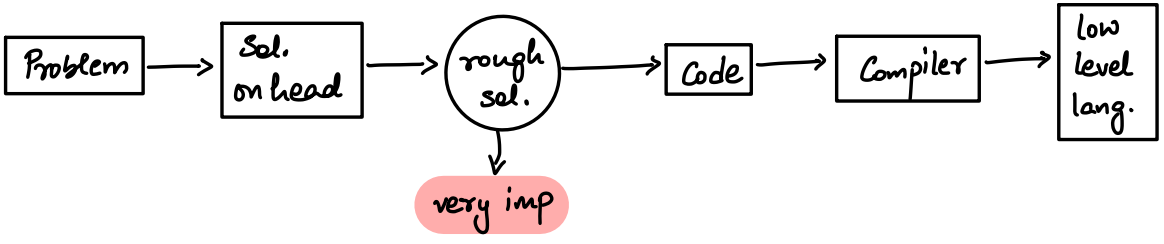
W1-L1

Thought process to solve a problem-

→ Understand a problem

→ input values

→ find approach

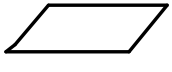


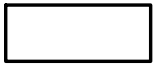
Algorithm- Sequence of steps

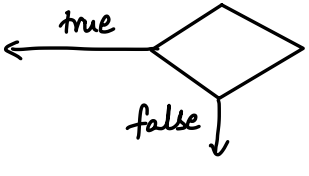
Flowchart- Graphical representation of algo

Components-

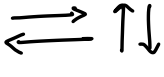

terminator for start /end

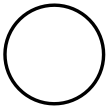

for input /output read /write


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

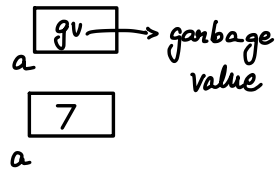
cout << endl; → for next line

cout << '\n';

int a ; ⟶ a is an integer

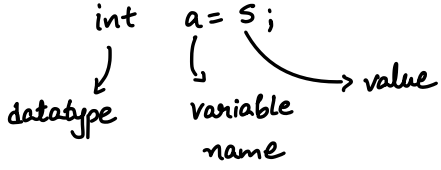
cin >> a ; ⟶ input a from user

ex-7



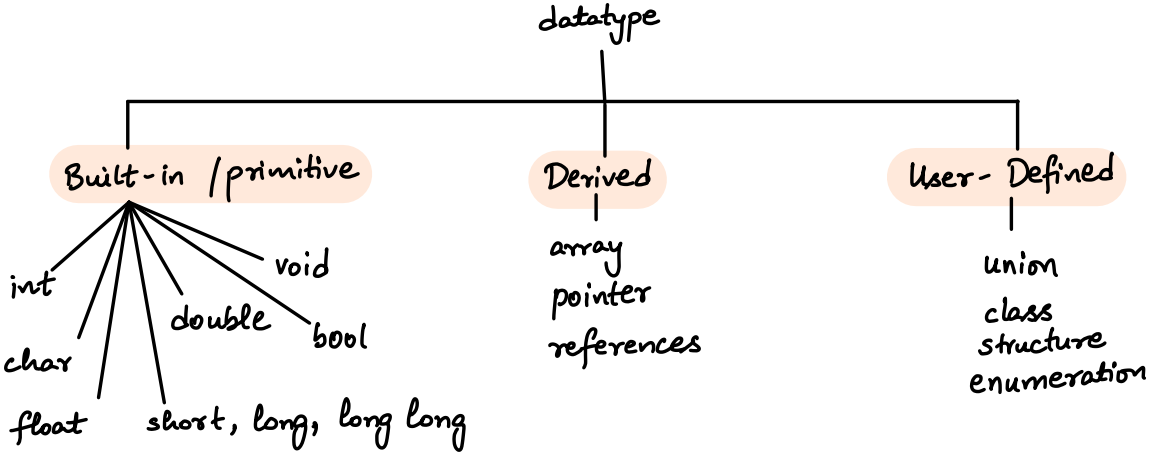
Variables

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

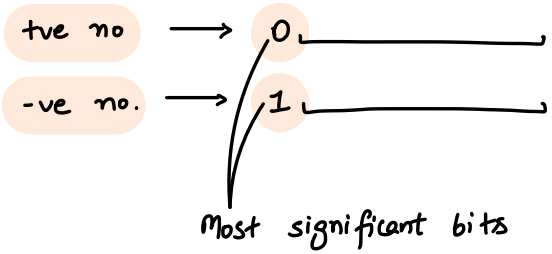
long → 4 byte → 32 bits

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

1....11001

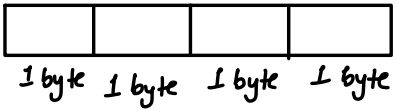
→ 1's complement ⟶ 0...00110

2's complement ⟶ 0...00111

→ +7

-7

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

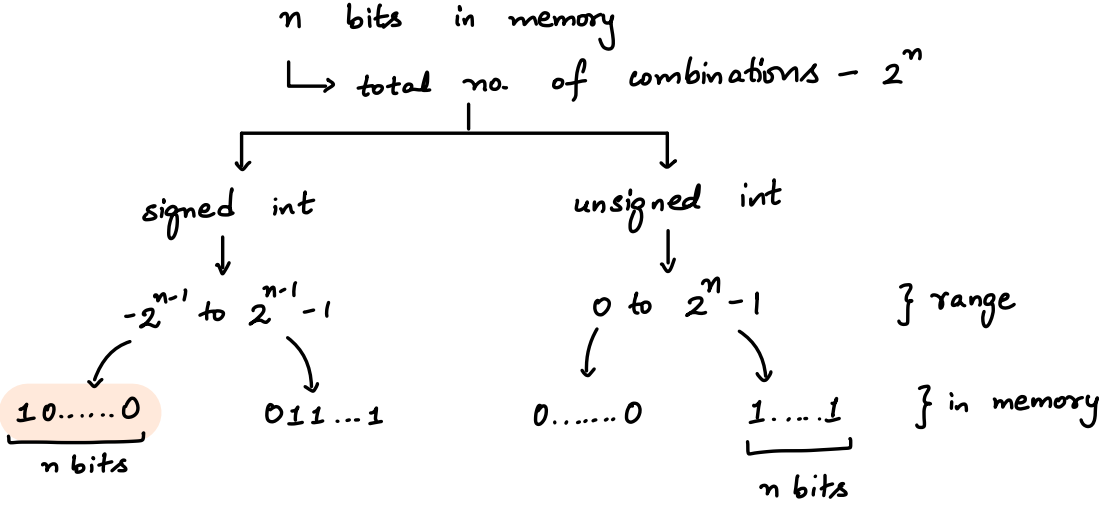
Signed vs Unsigned

- 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

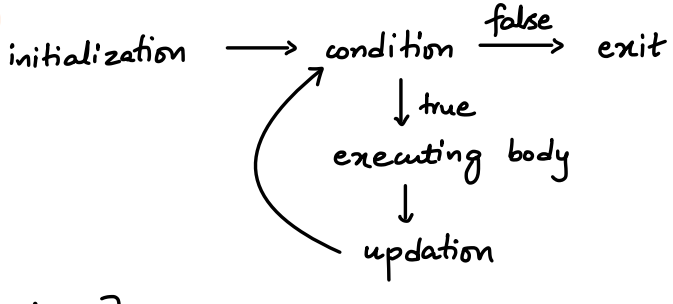
for - loop

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

↓

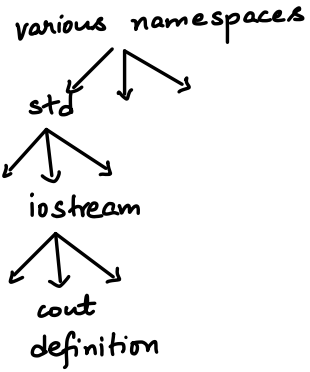
std namespace

↓

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

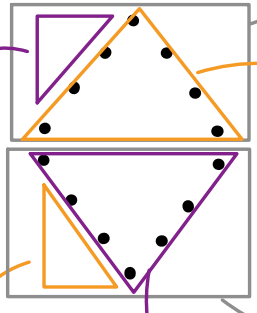
no. of times loop runs
0
0
1
2
3

→ 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

↳ Links.txt in repo

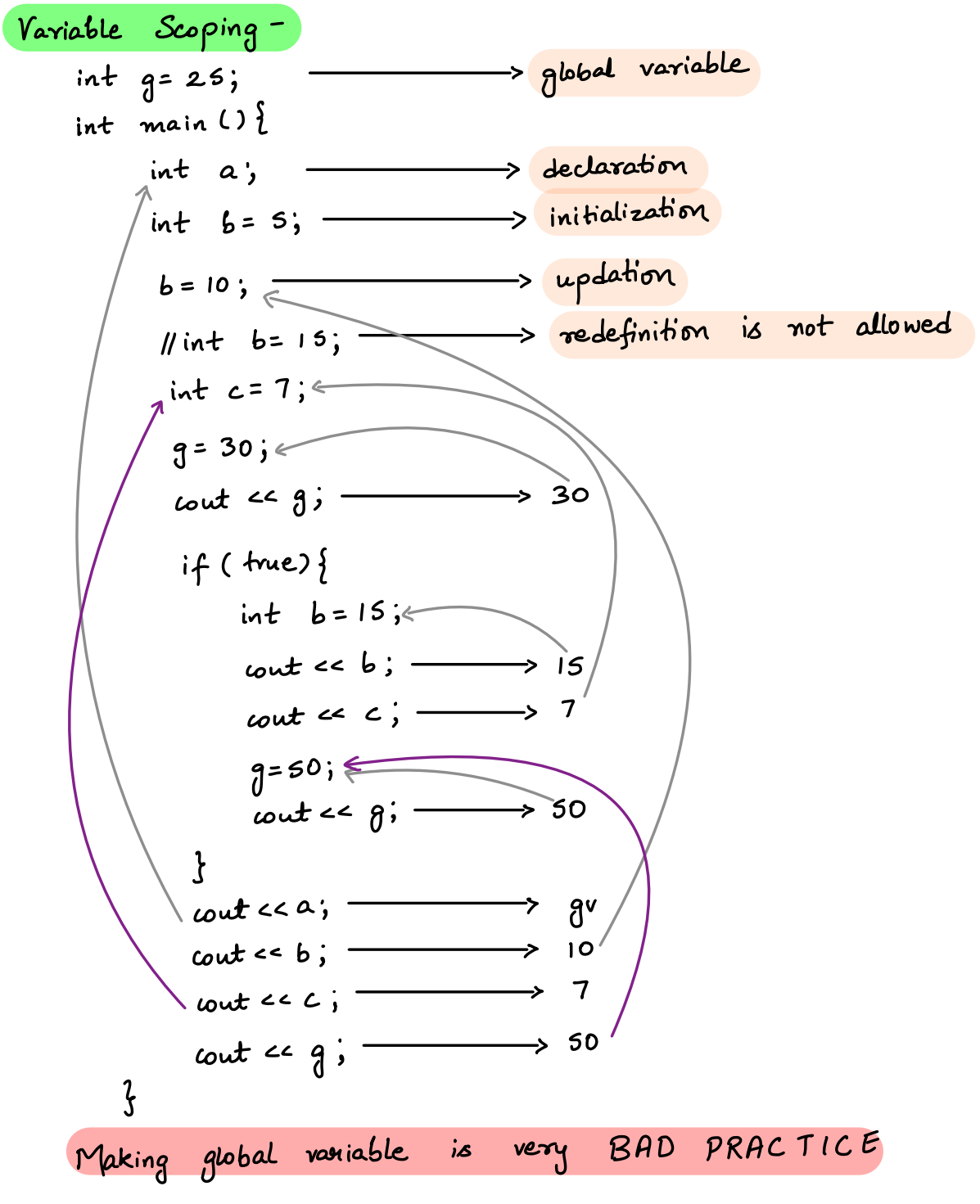
break and continue

break

↳ exit from that loop

continue

↳ skip that iteration


Variable Scoping -
int g= 25;
global variable
int main (){
int a;
declaration
int b= 5;
initialization
b = 10;
updation
//int b= 15;
redefinition is not allowed
int c= 7;
g= 30;
cout << g;
30
if (true){
int b= 15;
cout << b;
15
cout << c;
7
g=50;
cout << g;
50
}
cout << a;
gv
cout << b;
10
cout << c;
7
cout << g;
50
}
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

→ main cant have return type other than int in offline compiler

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

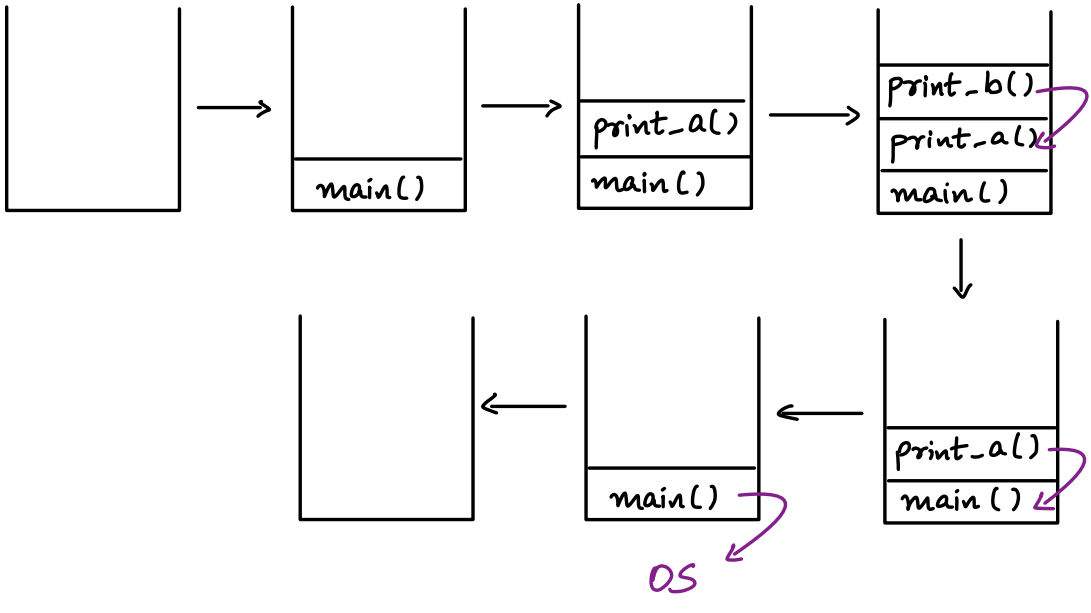
ex-

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

return to OS

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

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



Pass by value

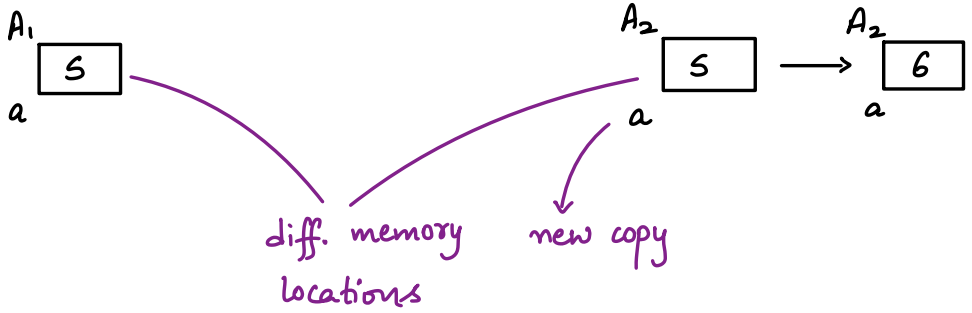
↳ a copy will be created of variables

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

argument

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

parameter



Address Of Operator &

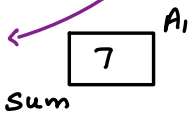
```
int n = 5;
cout << &n;
```

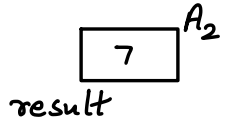
⟶ output - address of n

```
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

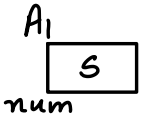
% operator ⟶ heavy operator

↳ 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 → memory location of variable

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;
while (i<5){
    cout<< i <<endl;
    i++;
}
```

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

flow

initialization → condition → (false) → exit

condition → (true) → body (containing updatation) → condition

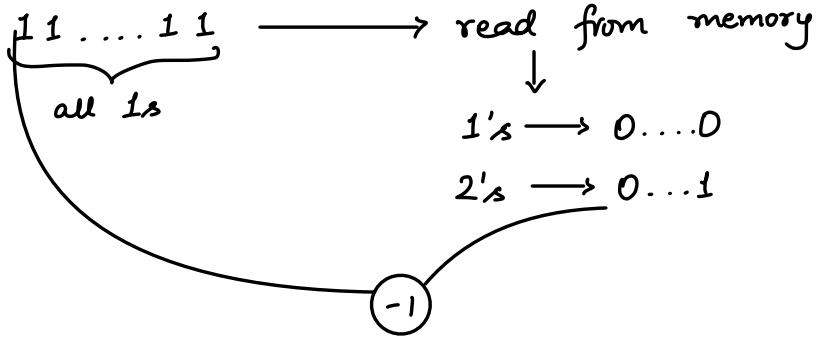
left and right shift operators

```
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

How -1 is stored in memory -



~a = -(a+1) and ~(~a) = a

ex - a = 5; ⟶ 0...0 1 0 1

a= ~a; ⟶ 1...1 0 1 0 ⟶ -6 ⟶ -(5+1)

read ↳ 2's ⟶ 0...0 1 1 0

-6

a= -6;

↳ 1...1 0 1 0

a= ~a; ⟶ 0...0 1 0 1

↳ 5 ⟶ -(-6+1)

W2-R

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

W3-R

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

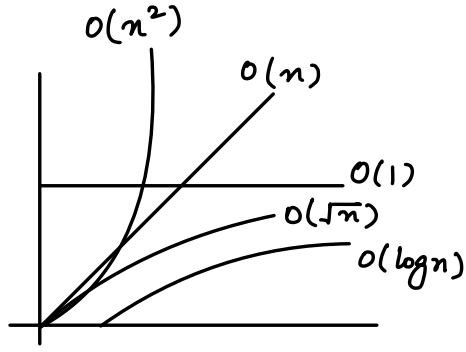
$O(1)$ ⟶ Constant time

$O(n)$ ⟶ 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

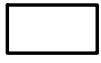
int a[30000]; ⟶ 30000 variables are ready

continuous memory location

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

int a = 5;

A



a

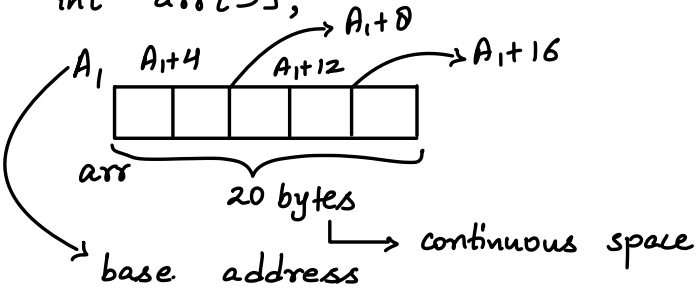
symbol table

int a ⟷ A

int arr ⟷ A_1

Declaration

int arr[5];



```
cout << arr ;  ------>  A1
cout << &arr ;  ------>  A1
```

Initialization

```
int arr[] = {2,4, 6, 8, 10};
int arr2[5] = {2, 4, 6, 8, 10};
int arr3[10] = {2, 4, 6, 8, 10};  ------> remaining 5 will be 0
//int arr4[4] = {2,4, 6,8, 10};  ------> ERROR
int arr5[10] = {0};  ------> initializing all values with 0
```

Making array at runtime

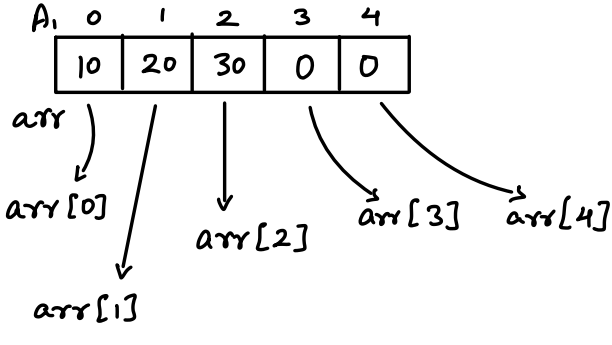
```
int n;
cin >> n;
int arr[n];  ------> BAD PRACTICE
```

Index and Access in memory

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

→ 0th 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)

thats why 0 based indexing → due to internal working

taking input in array

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

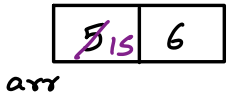
Arrays and Function

```
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;
}
```



sizeof(int); ⟶ 4 ⟶ in bytes

int arr[5];

sizeof(arr); ⟶ 20 ⟶ in bytes

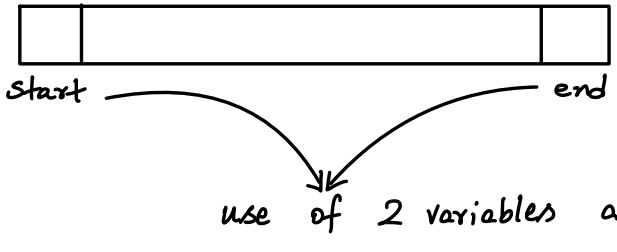
linear search in array

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

To find size of array

```
int arr[] = {1, 2, 3, 4};
int size = sizeof(arr) / sizeof(int);
```

sizeof(int) → datatype

W3-L2

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
- pass by value in functions

Initialization

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

```
vector <int> arr (5);
```
→ | 0 | 0 | 0 | 0 | 0 |

```
vector <int> arr (5, -2);
```
(5 → size, -2 → value)
→ | -2 | -2 | -2 | -2 | -2 |

```
int n;
cin >> n;
```
→ let n = 5

```
vector <int> arr(n);
```
→ | 0 | 0 | 0 | 0 | 0 |

```
vector <int> arr (n, 10);
```
→ | 10 | 10 | 10 | 10 | 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(); ⟶ true if 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 << ' ';
}
```

2D Arrays

W3-L3

→ use case

→ to work on multiple rows and columns

Declaration -

```
int arr[m][n];
```

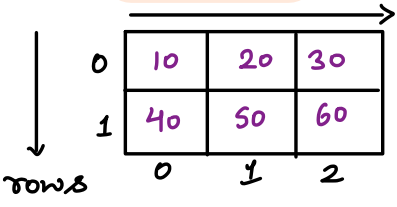
→ m*n elements

→ cols → 0 to n-1

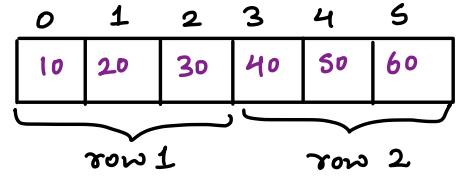
→ rows → 0 to m-1

```
int arr[2][3];
```

Visualize -



in memory -



Access -

```
arr[i][j];
```

→ col index $0 \le j < n$

→ row index $0 \le i < m$

Mapping -

```
linear_index = c * i + j
```

no. of cols

row index

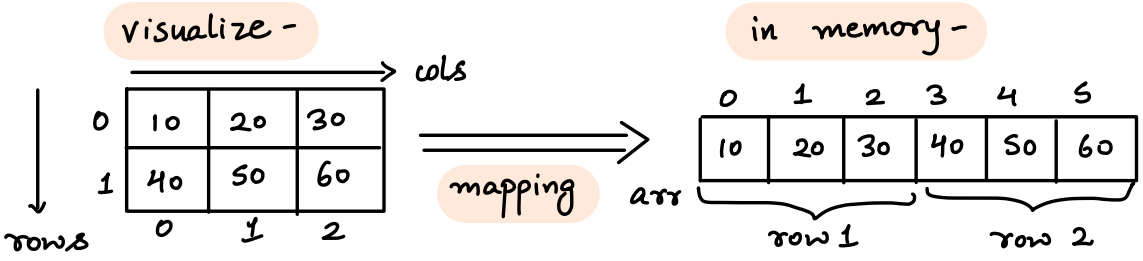
col index

$i = linear\_index / c$

j

Initialization -

```
int arr[2][3] = {{10,20,30}, {40,50,60}};
```



2D Arrays and function -

→ pass by reference

```
func( arr[][500], int rows, int cols)
```

→ cannot leave blank

why

this value and no. of cols in array passed in func should be same

if dont know, put large value

for mapping

→ linear_index = c * i + j

→ So that compiler can know

2D Array -

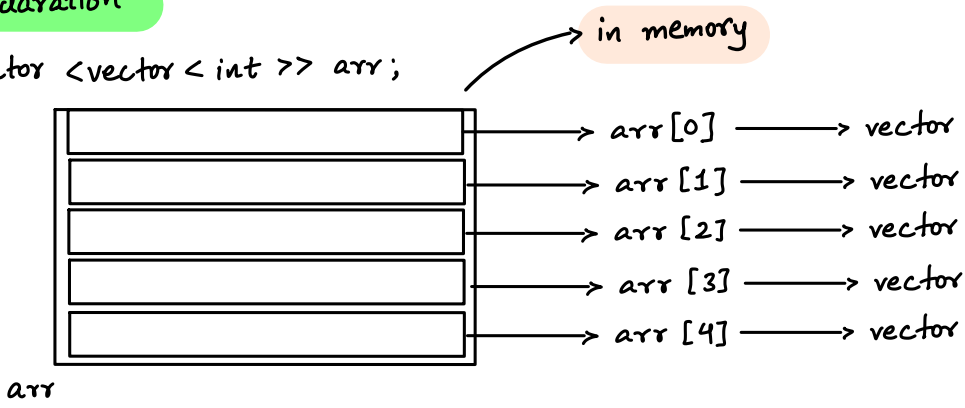
→ to make dynamically

→ vector of vectors

2D Vector

Declaration -

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



Declaration -

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

n → no. of rows

Number of rows

```
arr. size ()
```

Number of cols

```
arr [i]. size ()
```

- → in ith row
- → size of ith row

Initialization

```
vector < vector <int > > arr ;
vector < vector < int > > arr ( rows , ( vector <int > (cols , value ));
```

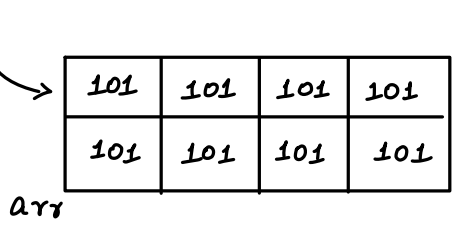
size ↑ rows

value ↑ vector<int>(cols, value)

initialization of 1D vectors in arr

- rows → no. of rows in arr
- cols → no. of cols in arr
  - → size of 1D arrays
- value → initial value in all elements of all 1D vectors

```
vector<vector<int>> arr(2, vector<int>(4, 101));
```



Searching and Sorting

W4-L1

Searching

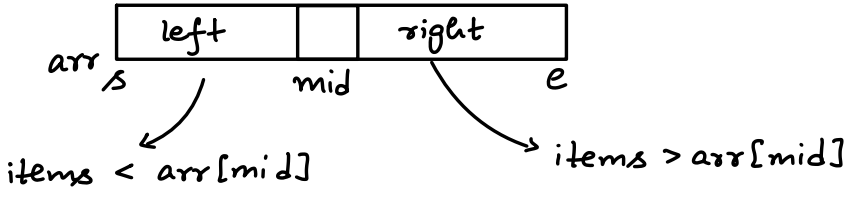
Linear Search

```
int linearSearch ( vector <int> arr, int target ) {
    int n = arr.size();
    for( int i=0; i<n ; i++){
        if ( target == arr[i])
            return i;
    }
    return -1;
}
```

T.C - O(n)

Binary Search -

- condition → sorted order → monotonic function
- binary → 2 → start and end pointers



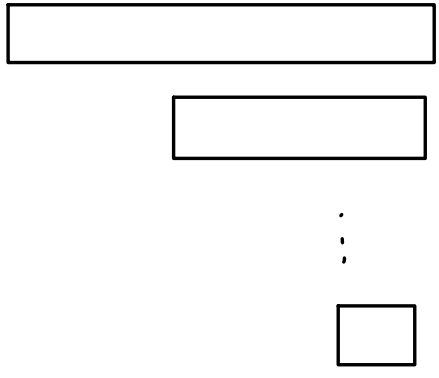
```
int binarySearch ( int arr[], int n , int target ){
    int s= 0, e= n-1;
    int mid = s+(e-s)/2;
    while( s<=e) {
        int element = arr[mid];
        if (target == element)
            return mid;
        else if ( target < element)
            e = mid - 1; ----> search in left subarray
        else
            s = mid +1; ----> search in right subarray
        mid = s + (e-s)/2;
    }
    return -1;
}
```

issue in $mid = \frac{s+e}{2}$; ⟶ int overflow if $s+e < INT\_MAX$

⟶ so use $mid = s + \frac{e-s}{2}$;

T.C - $O(\log_2 n)$

T.C. of binary Search



at last $\frac{n}{2^k} = 1$

$k = \log_2 n$

So loop runs $\log_2 n$ times

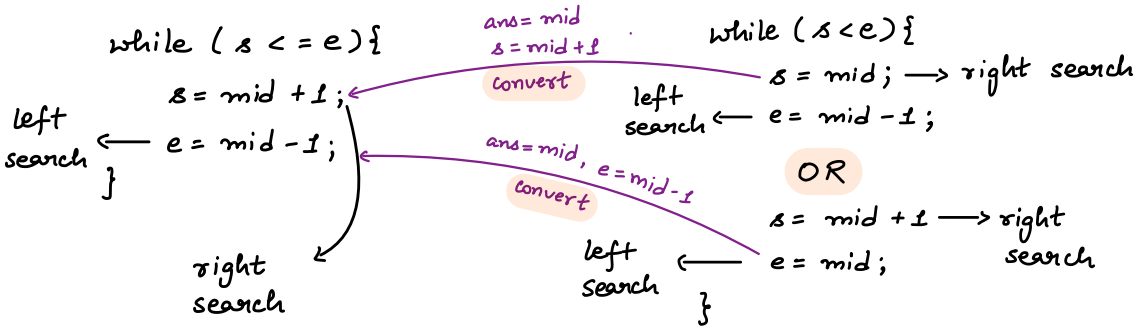
T.C. = $O(\log_2 n)$

W4-L2

→ Search Space

- → find range of search space (start & end) in ques of. Binary Search Questions
- → store mid in ans if needed

→ In binary search questions



W4-L3

cout << (int)(-3.74);

↳ -[int(3.74)]

↳ -(3) → -3

cout << (-22)/7; → -3

cout << 22/(-7); → -3

Types of ques in binary search

→ 1st type → classic questions

↳ lower bound

upper bound

peak in mountain array

pivot in sorted rotated array ← can also find array is sorted or not

↳ pivot index = n-1

search in sorted rotated array

→ 2nd type → find in search space (range)

- → predicate function → logic to decide either left or right
- → sqrt of a no.
  divide 2 numbers

Advance Binary Search Problems

- → Book allocation
  Painters Partition
  Aggressive Cows
  Roti / Paratha Spoj
  Eko Spoj

→ 3rd type → observation in index

- → missing element in sorted array
  odd appearing element in array

W4-L5

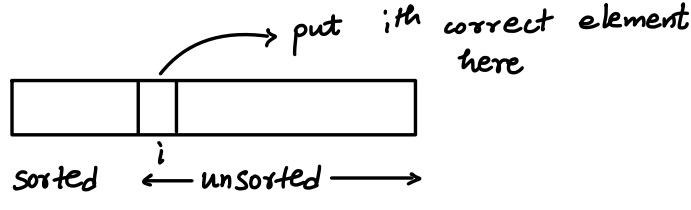
Sorting

- → putting all elements either in increasing order or decreasing order

Selection Sort -

- select minimum element and put it in its right position
- select correct element for i^{th} index
  - minimum

```
void selectionSort ( int arr[], int n) {
    for(int i=0; i<n-1; i++){
        mini = i;
        for ( int j= i+1 ; j<n ; j++) {
            if ( arr[mini] > arr[j])
                mini = j;
        }
        swap (arr[i], arr[mini]);
    }
}
```



T.C. $O(n^2)$

S.C. $O(1)$

Use Case - for small size array

Bubble Sort -

→ in i^{th} round put i^{th} largest element to its correct position using adjacent comparisions

```
void bubbleSort ( int arr[], int n){
    for(int i=0 ; i<n-1 ; i++) {
        bool swapping = false;
        for( int j= 0 ; j<n-i-1 ; j++){
            if (arr[j] > arr[j+1]) {
                swap ( arr[j], arr[j+1]);
                swapping = true ;
            }
        }
        if ( swapping = = false)
            break;
    }
}
```

T.C. - $O(n^2)$ → worst and average case (→ reverse sorted)

$O(n)$ → best case → already sorted

S.C. - $O(1)$

Use Case - To put i^{th} largest element to its correct position

Insertion Sort -

↳ take an element and insert it on its correct position by shifting

```
void insertionSort ( int arr [ ], int n ) {

    for ( int i = 1 ; i < n ; i++ ) {
        int curr = arr [ i ];
        int j = i - 1 ;
        for ( ; j >= 0 ; j-- ) {
            if ( arr [ j ] > curr )
                arr [ j+1 ] = arr [ j ] ; // shifting
            else
                break ;
        }
        arr [ j+1 ] = curr ; // inserting
    }
}
```

T.C. - $O(n^2)$ ⟶ worst & average case

$O(n)$ ⟶ best case

S.C. - $O(1)$

Use Case - When array is small or when array is partially sorted

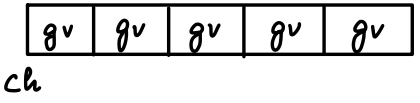
CHAR ARRAYS & STRING

W5-L1

Char Arrays -

- Data structure ⟶ used to store data
- Not Data type ⟶ tells type of data

```
char ch[5];
```



Taking input in char array

```
char ch[7];
cin >> ch[i];
```

`cin >> ch;` ⟶ by defaut NULL char will insert at end ⟶ '\0'

↓

NULL char shows string termination

- cin reads until it gets any white space
  - space ' '
  - tab '\t'
  - endl '\n'

`cout << ch;` ⟶ print until it gets delimeter

```
char ch[10];
```

`cin >> ch;` ⟶ Ujjwal

store in buffer memory

'U'	'j'	'j'	'w'	'a'	'l'	'\0'

buffer

copy in memory of ch

	'U'	'j'	'j'	'w'	'a'	'l'	'\0'	gv	gv	gv
ch	0	1	2	3	4	5	6	7	8	9

`cout << ch;` ⟶ Ujjwal ⟶ stops after 'l' because of '\0' char

Overflow -

```
char ch[4];
```

`cin >> ch;` ⟶ Ujjwal

`cout << ch;` ⟶ Compiler Dependent

get line

cin.getline (char array, max char to write, delimeter);

char where taking input stops

by default '\n' ⟶ enter

ex- cin.getline (ch , 50);

cin.getline (ch , 50, ' ');

Char arrays and function

↳ pass by reference

```
func ( char ch[]){

}
```

size of char array ⟶ $\frac{\text{sizeof (ch)}}{\text{sizeof (char)}}$

Some inbuilt functions of char array

strlen (ch) ;

strcmp (ch1, ch2);

strcpy (ch1 , ch2);

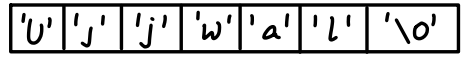
Strings

- Datatype
  Not DataStructure
- Dynamic char array
- NULL char at last of string

string str; ⟶ empty string created

cin >> str; ⟶ Ujjwal

cout << str; ⟶ Ujjwal



str

getline -

```
string str;
getline (cin, str);
```

char array

```
char ch[100] = "B_abba_r";
cout << ch;
```
⟶ B_abba_r

```
ch[1] = '\0';
ch[6] = '\0';
cout ch;
```
⟶ B

↓

stops just as it gets NULL char

string

```
string str = "B_abba_r";
cout << str;
```
↳ B_abba_r

```
str[1] = '\0';
str[6] = '\0';
cout << str;
```
↳ Babbar

↓

Runs till the length of string