

1) graphs what?
Reers - Adj List
- Adj mat

2) DR

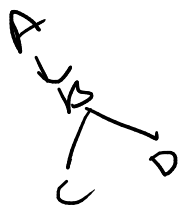
①

Travel DFS DFS

1) Recurisii

- 1) Recursion
- 2) Optimization \rightarrow memory size

2) optimize
3) sparse optimize



1) Number of islands

2) mit π hat

2

1) cycle

2) undirected

3) directed

4) undirected

2) Topological

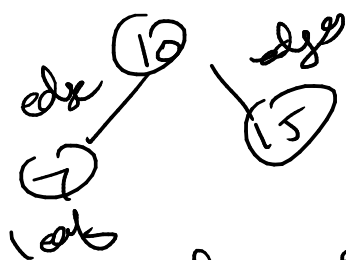
2) Course should be

3) Shortest Path
Dijkstra
Floyd Warshall

Cyrc^h

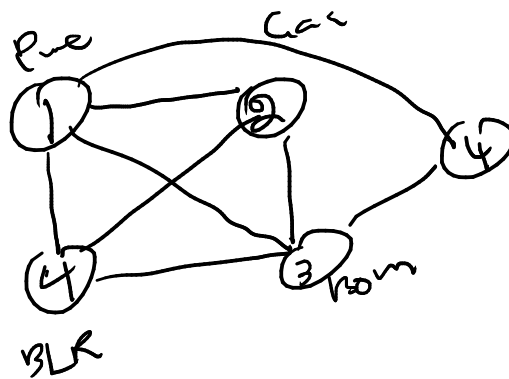
True

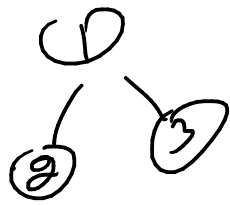
root set of vertices $\leq \deg$



no2

ed

$$n \rightarrow$$

$$n(e) = j$$

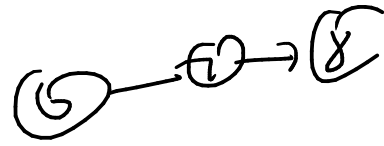
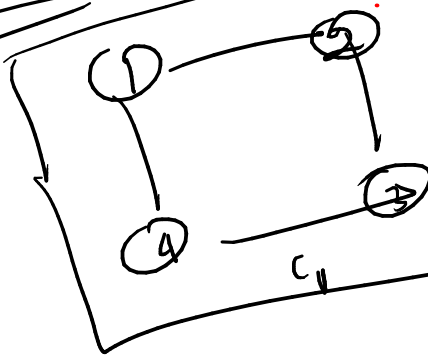


Tree \rightarrow graph \checkmark $n, n-1$

graphs \rightarrow Trees

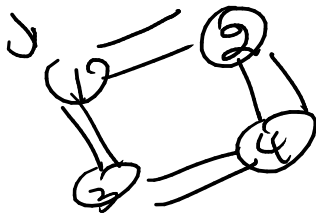
components of graph

not diff /



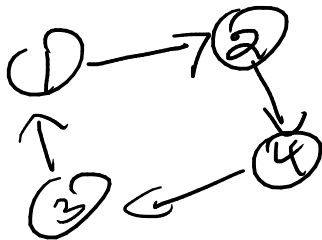
C_2

Simple graph

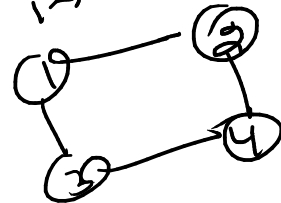


handshake
 $\hookrightarrow e \rightarrow 2V$
 $\hookrightarrow e = 8$

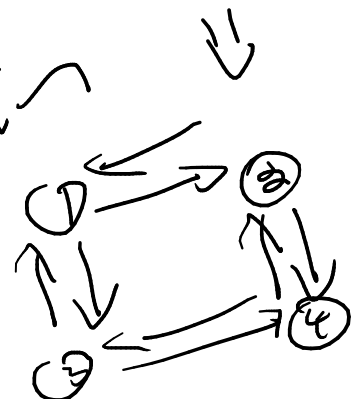
Directed



undirected graph

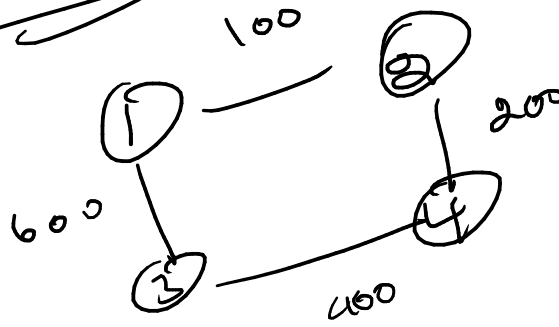


$1 \rightarrow 2$
 $2 \rightarrow 1$

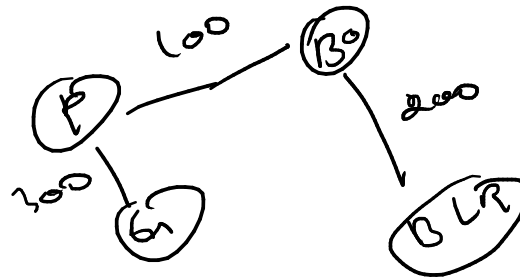


~~represent~~

weisthet

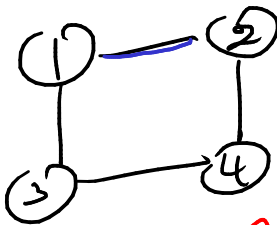


weisthet
undretel



represent

undretel



$arr[1][2] = 100$
 $arr[2][1] = 600$

1) Adj List

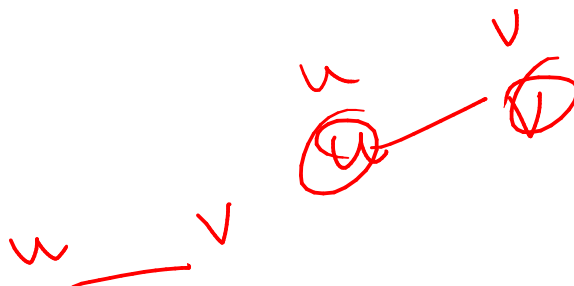
2) Adj matrix

$n \times n$ $(n+1) \times (n+1)$

	1	2	3	4
1		100	600	
2	600			200
3				400
4		200	400	

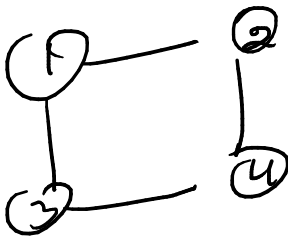
java

$O(n^2)$
 $arr[1][2] = 100$
 $arr[2][1] = 600$
 $arr[2][4] = 200$
 $arr[4][2] = 200$
 $arr[3][4] = 400$
 $arr[4][3] = 400$



$1 \rightarrow 1 \ 2 \ 3 \ 4$
 $2 \rightarrow 1$

ndis



$1 \rightarrow 2 \ 3$

$2 \rightarrow 1 \ 4$

$3 \rightarrow 4 \ 1$

$4 \rightarrow 2 \ 3$

4

4

$u \rightarrow v$
 $v \rightarrow u$

1 2

2 4

4 3

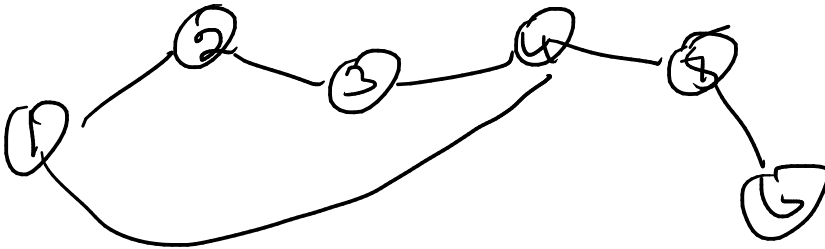
3 1

und-re

$1 \rightarrow n-1$

n^2

$n \times 2m$



$1 \rightarrow 2$

$2 \rightarrow 1 \ 3$

$3 \rightarrow 2 \ 4$

$4 \rightarrow 3 \ 5$

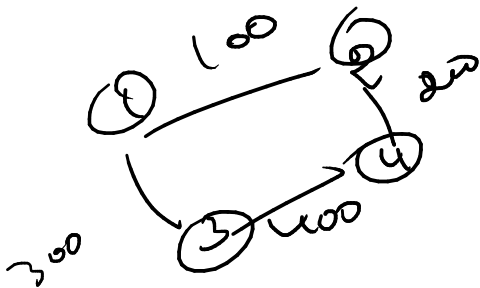
$5 \rightarrow 4 \ 6$

$6 \rightarrow 5$

n^2

$n \neq 2m$

$O(n^2)$



	1	2	3	4
1				
2		100		200
3				
4				

4

1 2 100

2 4 200

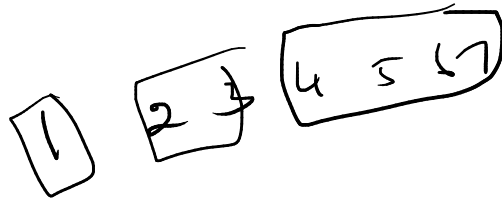
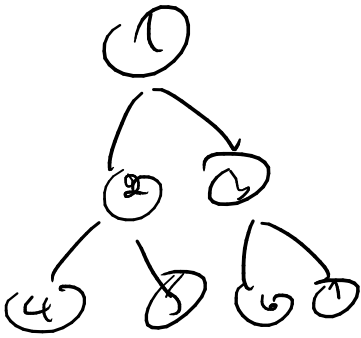
$1 \rightarrow \{2, 100\} \{3, 300\}$
 $2 \rightarrow \{1, 100\} \{4, 200\}$
 $\{4, 400\} \{1, 300\}$

3 4 400
1 3 300
3 → 2003 {3, 400}
4 → 2

Traverse
Level
ord

BFS (Breadth First Search)

DFS (Depth First Search)
↓
in-order

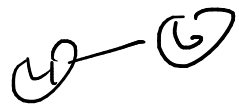
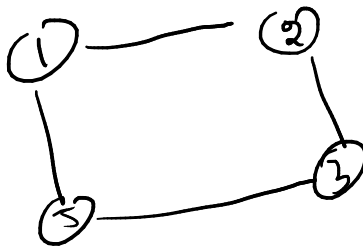


As son → go inside

Adj

DFS

1 2 5
2 3 1
3 2 5
4 6
5 1 3
6 4



c2

c1

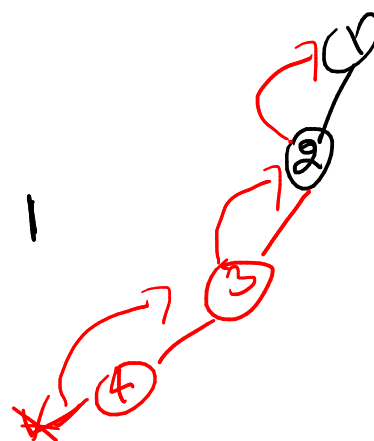
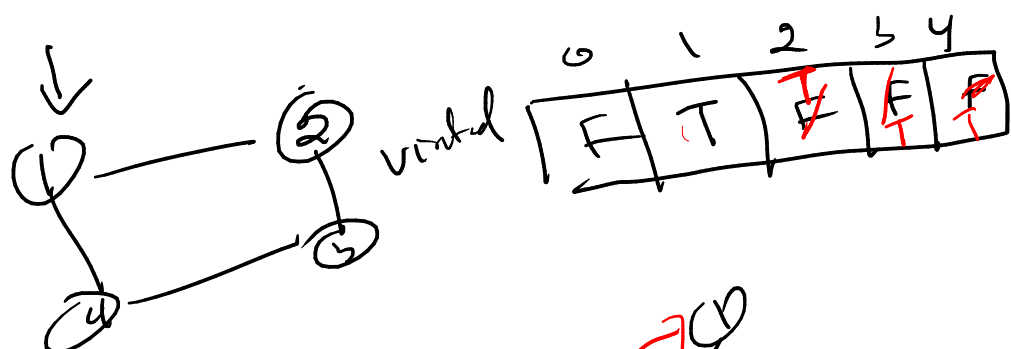
DFS → 1 2 3 5 4 6

Handwritten diagram of a binary tree structure. The nodes are labeled with numbers 0 through 12. Nodes 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 are shown. Some nodes are crossed out with red lines: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. The tree structure is as follows:

- Node 0 is the root.
- Node 0 has children 1 and 2.
- Node 1 has children 3 and 4.
- Node 2 has children 5 and 6.
- Node 3 has children 7 and 8.
- Node 4 has children 9 and 10.
- Node 5 has children 11 and 12.

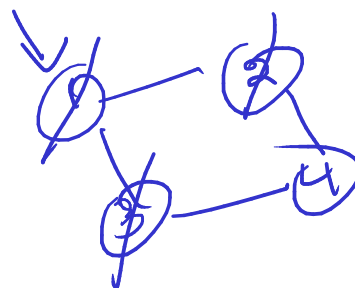
Annotations include:

- Red lines crossing out nodes 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12.
- Red arrows pointing to nodes 4 and 5.
- Red text "11" and "12" near the bottom left.
- Red text "12" near the bottom right.
- Red text "12" near the bottom right.
- Red text "12" near the bottom right.



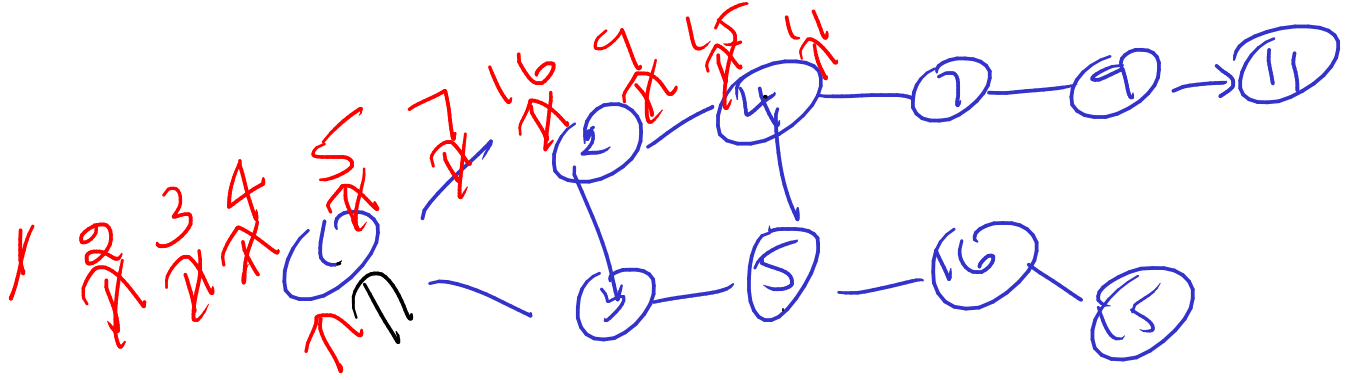
BTS

1 2 3 4



MF3
pfs → andhra
dear

1 2 3
2 4 4
3 1 4
4 2 3

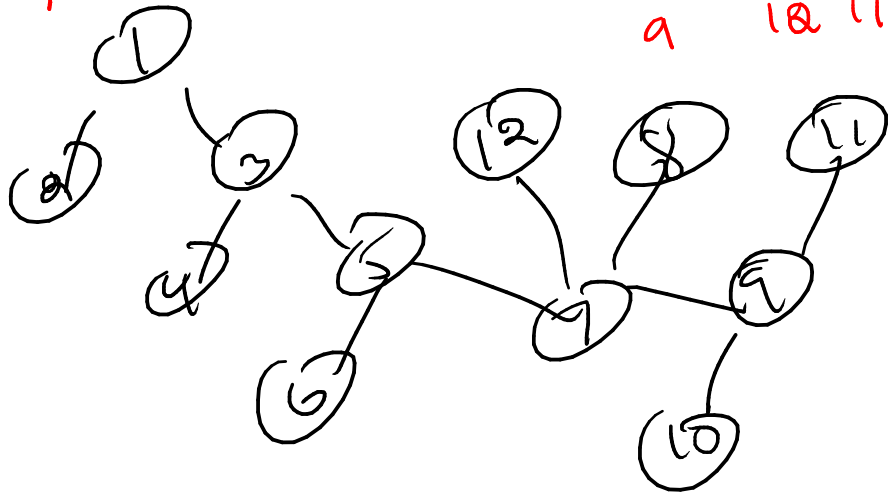


1 2 3 4 5 7 16 9 15 11

ans
~~1~~ ~~2~~ ~~3~~ ~~4~~ ~~5~~ ~~6~~ ~~7~~ ~~8~~ ~~9~~ ~~10~~ ~~11~~ ans
Ans

1 2 3 4 5 6 7 8
 9 10 11 10

15 15



Solution

WR

Solution

1) cycle graph

→ gular

mark → 2022

2) number islands
 3) max or less

4) maximize graph

- 1) $s \rightarrow \text{end} \quad \{ \}$
- 2) rotten orange
- 3) cycle det
 - \hookrightarrow undirected $\begin{cases} \text{DFS} \\ \text{BFS} \end{cases}$
 - \hookrightarrow directed $\rightarrow \text{DFS}$
- 4) Bipartite

st end
2 100

$\{ \underline{2, 5, 100} \}$ ①

$$2 \times 5 \times 5 \times 2 = 4$$

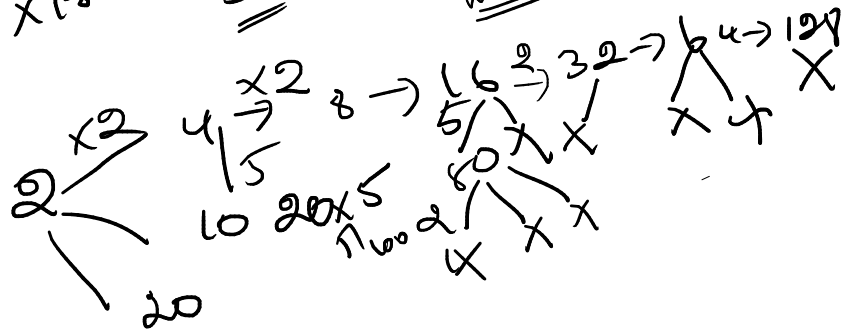
$$2 + 5 \times 10 = 3$$

minimal

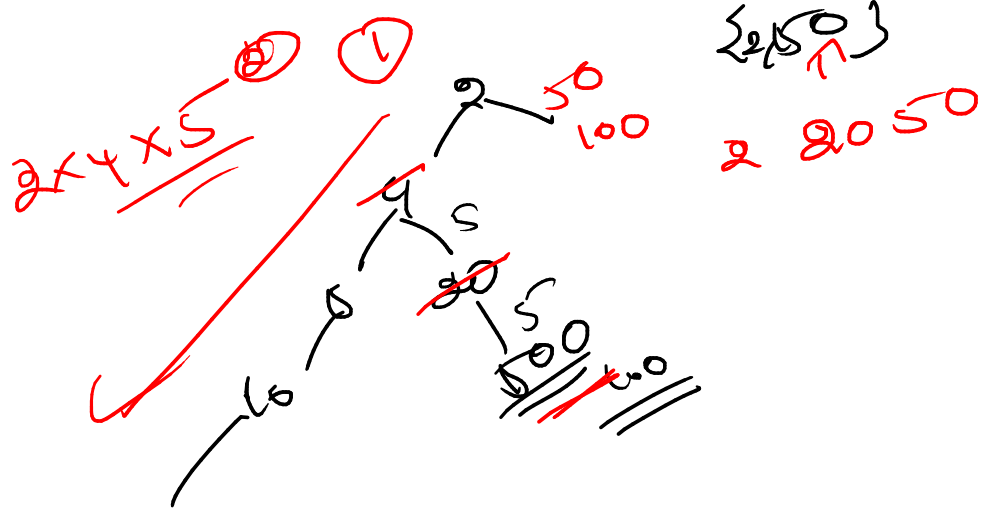
DFS

$$= 100$$

DFS

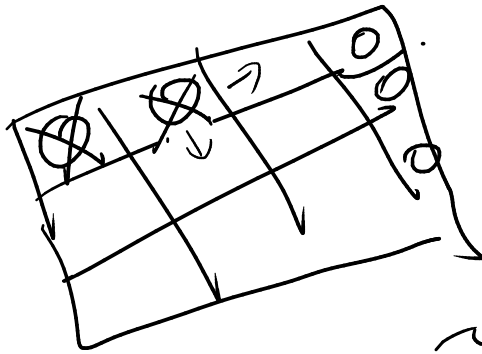


DFS



0 → empty
1 → no ref
2 → ref

cut all
edges //



all ors

cut →

//

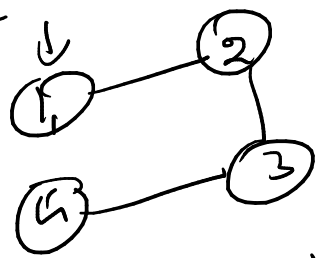


DFS

cycle

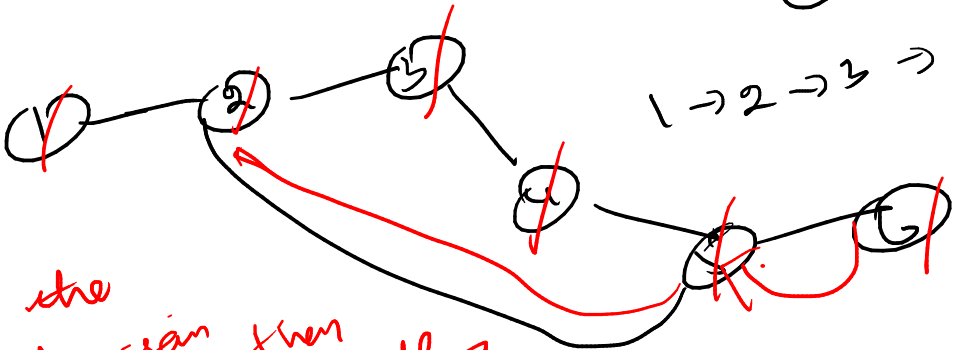
cycle is true / false

Assume



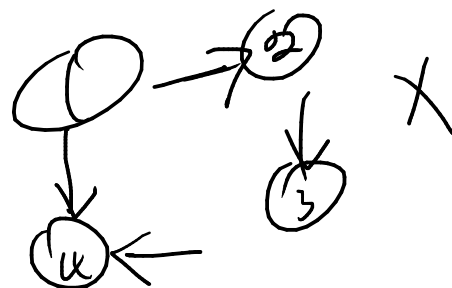
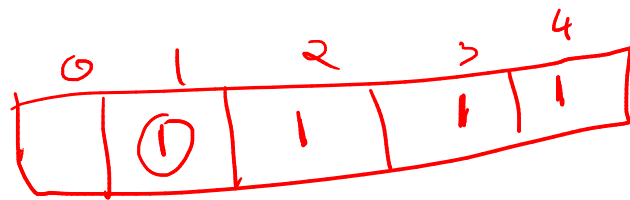
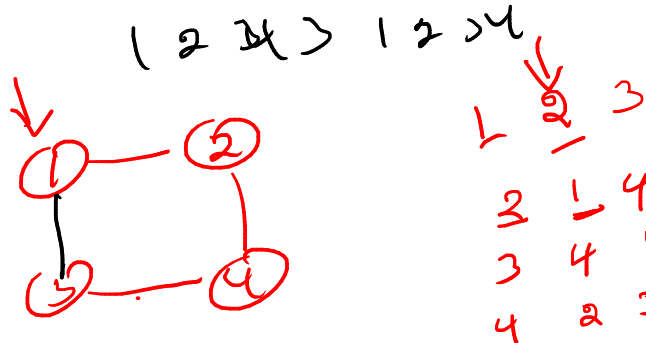
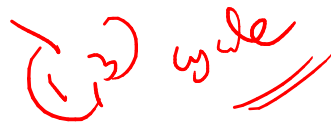
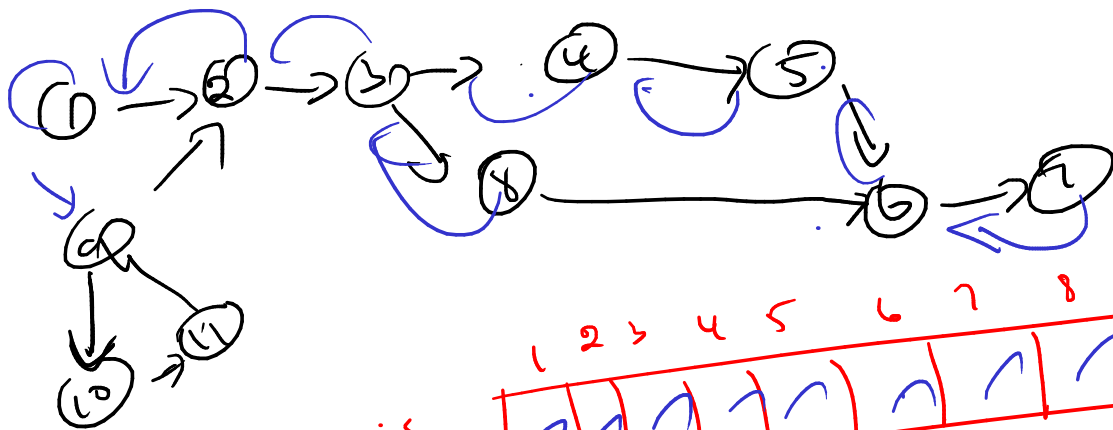
1 → 2 → 3 → 4 → 5 → 1

DFS



visit the
node again then
cycles

5 → 4 → 2


$$1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow$$


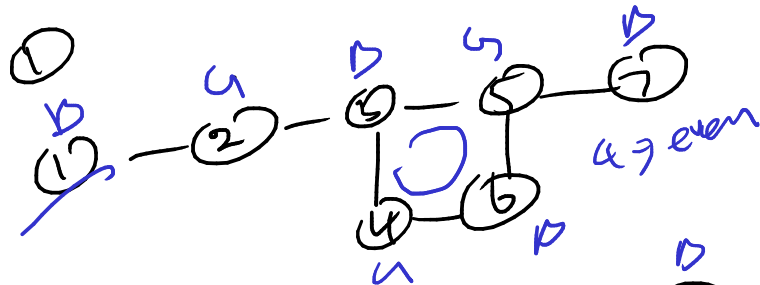
۷۱

der ist

The top diagram shows a grid of numbers 1 to 11. The numbers 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 are marked with blue checkmarks, indicating they are prime. The number 1 is not marked.

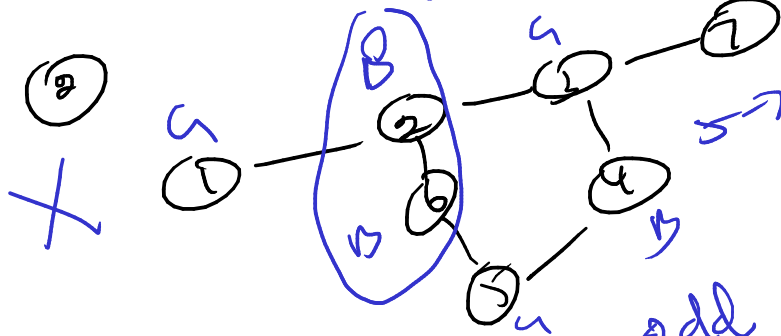
The bottom diagram shows the same grid of numbers 1 to 11. The numbers 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 are marked with blue 'X' marks, indicating they are composite. The number 1 is not marked.

- 1) Bipartite
- 2) Topo sort
- 3) Shortest path



Bipartite

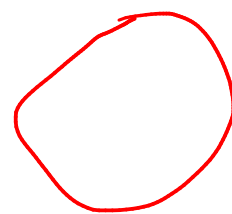
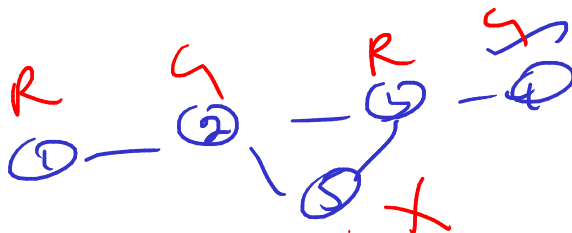
color whole graph
with only 2



odd

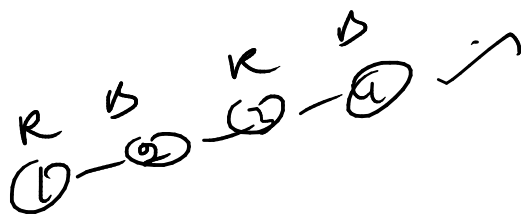
colors →
no two adjacent
node should
have same
color

odd cycle X

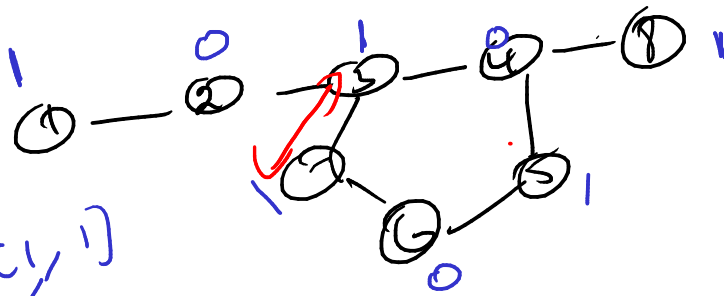


R B R B

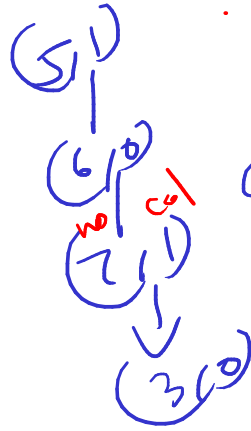
cycle length → odd



(cycle length) / 2 = 1) X
dx



0 → R
1 → D
- → Not rel

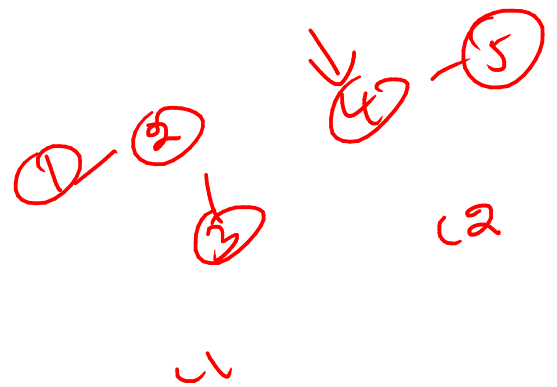
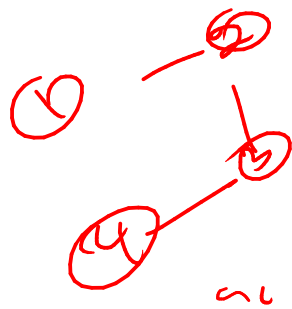


don

0	1	2	3	4	5	6	7	8
-	1	1	1	2	1	1	1	1

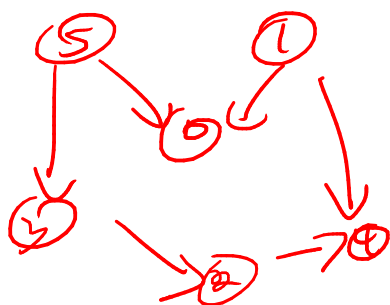
3

↑
2 (color == col) X



topological sort DAG

linear ordering of vertices



order

15 0324

5 1 0 3 2 4

u → v → u had all way
before v

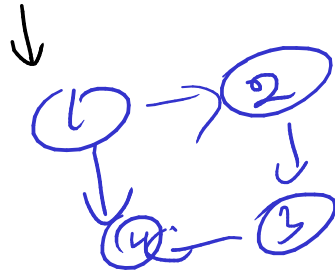
- 1) No cycle
- 2) Directed



① → ② ① → ②

1 2 3 1 2

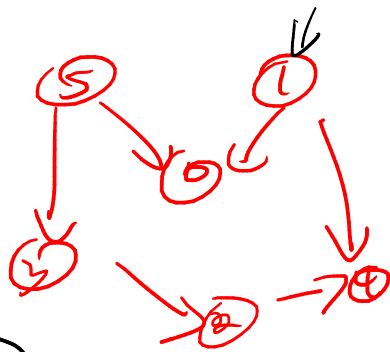
DAG



40

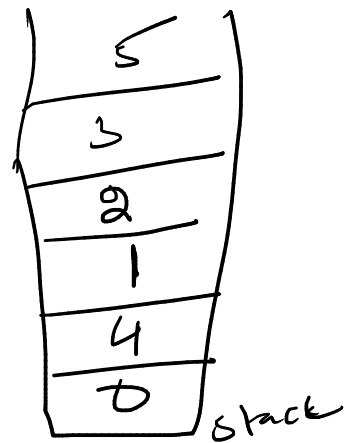
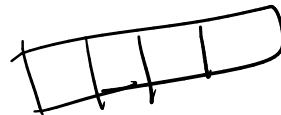
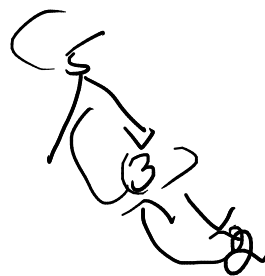
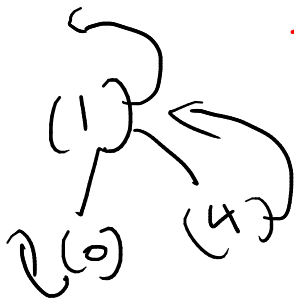
1 2 3 4

1 4 2 3



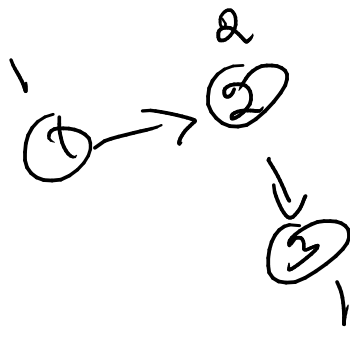
1) DFS

2) BFS → Kahn's Algo



5 3 2 1 4 0

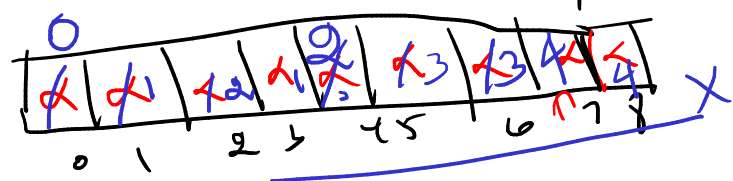
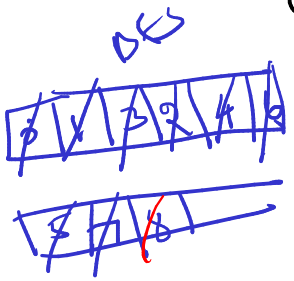
BFS



indge 0 1 1
outde 1 1 0

- 1) Topo
- 2) Shortest
 - ↳ undirected (1)
 - src → all nodes?
 - BFS/DFS
 - ↳ Dijkstra

undirected with int weights

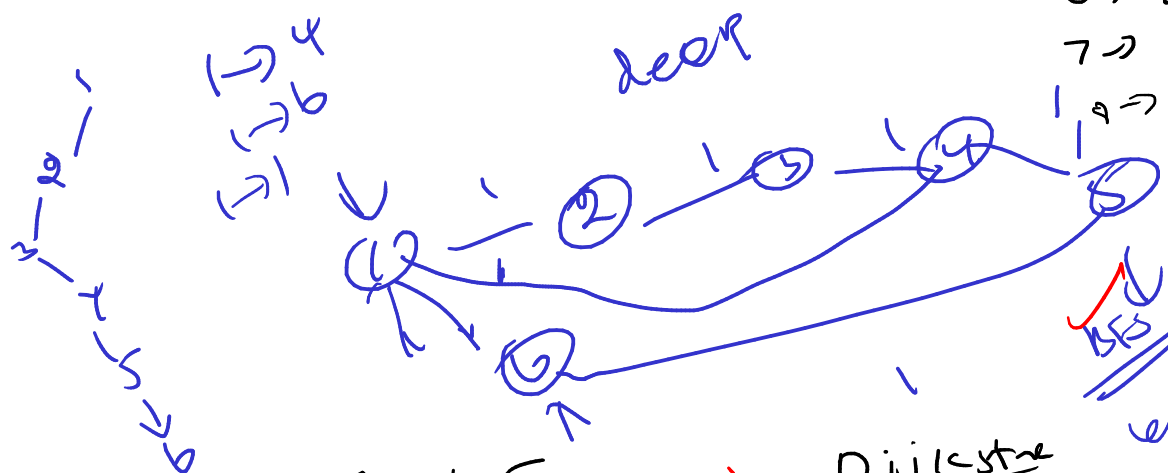


0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9

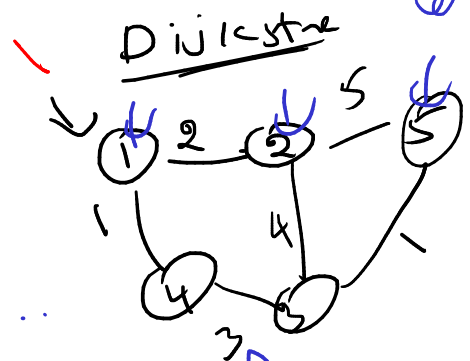
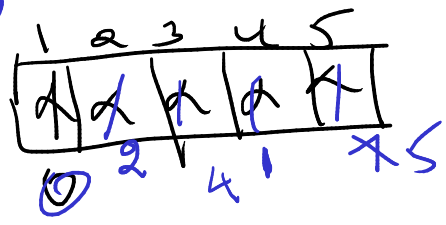
src = 0
all nodes?

dfs
0 → 1 3
1 → 0 2 4
2 → 1 6
3 → 0 4
4 → 3 5
5 → 4 6
6 → 2 5 7 8
7 → 6 8
8 → 7 8

deep

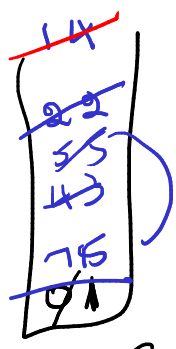


dfs
Some more reach



negative val

Greedy



min cost node

set

negate



1 2 2 4 1
2 1 2 5 5 3 4
3 2 4 4 3 5 1
4 1 1 3 3
5 2 5 3 1