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Academic Year	Module	Assessment Number	Assessment Type
S20	Introductory Data Structures and Algorithms (DipIT02)	A1	Not so easy question

[Not So Easy Question]

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Section : [DC8]

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1-> Abstract data type are those type or class whose behaviour is defined by a set of value and a set of operations. It is usually implemented by an array.

The array and array type is also known as an abstract data type which hold a collection of elements that are accessible by an index. The elements which are stored in an array can be anything through primitive type for example: instances of classes which can be integer to more complex types.

Following are the areas in which data structure are applied extensively:

In Linear
-> Array
-> Link-list
-> Stacks
-> Queues

In Non-Linear
-> Trees
-> Graphs
-> Tables
-> Sets

2 → Asymptotic analysis of an algorithm refers to defining the mathmatical boundation / framing of its runtime performance. Therefore 1 sec is equal to 1×10^6 micro second.

	1 Sec	1 Min	1 Hour	1 Day	7 Day	15 Day	1 Month
$\log\log n^2$	$2^{5\times10^5}$	$2^{3\times10^7}$	$2^{1.8\times10^9}$	$2^{4.32\times10^{10}}$	[illegible]	$2^{6.048\times10^{11}}$	$2^{1.314\times10^{12}}$
$\sqrt{n}$	1×10^{12}	3.6×10^{15}	1.29×10^{21}	7.46×10^{21} [illegible]	3.6×10^{23}	1.6×10^{24}	6.7×10^{24}
$2n^3$	79	310	1216	3508	6712	8654	10903
2^n	19	25	31	36	39	40	41
$n!$	9	11	12	13	14	14	15

Hence, from the table the $\log n^2$ is distinguished to be the best time complexity algorithm in compared to others. When we analyze the algorith, ordered by slowest to fastest growing: ~~then or the by good time~~ then, the best or good time complexity is:

$\log\log n^2 > \sqrt{n} > 2n^3 > 2^n > n!$

3)> Solution

Pseudocode

```
largestInteger(n)
i = 2^(n-1) - 1;
Print i;
```

for 1 bit

$2^1 = 2 = 0, 1$

for 2 bit

$2^2 = 4 = 0, 1, 10, 11$

for 3 bit

$2^3 = 8 = 0, 1, 10, 11, 100, 101, 110, 111$

for n bit

2^n

for 32 bit

$2^{32} = 4294967296$

for the largest integer

$2^{n-1} - 1$

$= 2^{32-1} - 1$

$= 2147483647$

4 -> Solu

Given: $(x+3y)*/(3z-p+2^t)$

Converting infix to postfix using stack:

S.N	Scanned	Stack	Post fix	Description
1	(	(	(	Start
2.	x	(	x	
3	+	(+	x	
4	3y	(+	x3y	
5	)		x3y+	
6	/	/	x3y+	
7	(	/(	x3y+	
8	3z	/(	x3y+3z	
9	-	/(-	x3y+3z	
10	p	/(-	x3y+3zp	
11	+	/(-+	x3y+3zp	
12	2^t	/(-+^	x3y+3zp2^t	
13	)		x3y+3zp+^+/	End

∴ the postfix value is x3y+3z-p+^+/

5->. Stack - is used to perform Recursion because of the Last In First Out (LIFO) property. which ~~is used to store~~ works by storing return addresses of the function calls.

For example: Pile of group of weights used in Gym machines.

In 'C' code

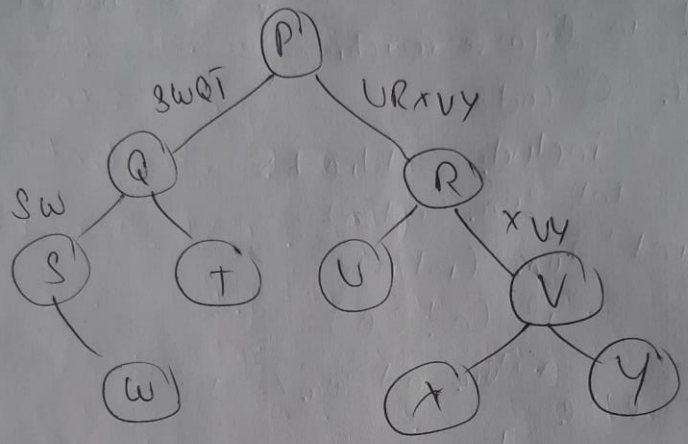
```
#include <stdio.h>
int sum(int n);
int sum (int n){
    if (n != 0)
        return n + sum(n-1);
    else
        return n;
}
int main(){
    int number, result;
    printf("Enter a positive integer");
    scanf("%d", &number);
    result = sum(number);
    printf("sum = %d", result);
    return 0;
}
```

6 → Solution.

Given:

Inorder traversal: SWQTPURXVY

Preorder Traversal: PQSWTRUVXY



7 → Solo

Given:

$T(n) = \begin{cases} 2 & \text{if } n = 2 \\ 2T(n/2) + n & \text{if } n = 2^k, \text{ for } k > 1 \end{cases}$

is $T(n) = n \log n$

Base step

If $n = 2$, then $T(n)$ $T(2) = 2^k$ $2 \log 2 = 2$

Thus, $T(2) = 2 \log 2$

Hypothesis step

Assuming $T(n) = n \log n$ is true if $n = 2^k$ for some integer $k > 1$.

Inductive step

If $n = 2^{k+1}$, then

$T(n) = 2T(2^{k+1}/2) + 2^{k+1}$

$= 2^1 (2^k) + 2^{k+1}$

$= 2(2^k \log 2^k) + 2^{k+1}$ [$\because T(n) = n \log n$]

$= 2^{k+1} ((\log 2^k) + 1)$

$= 2^{k+1} \log 2^{k+1}$

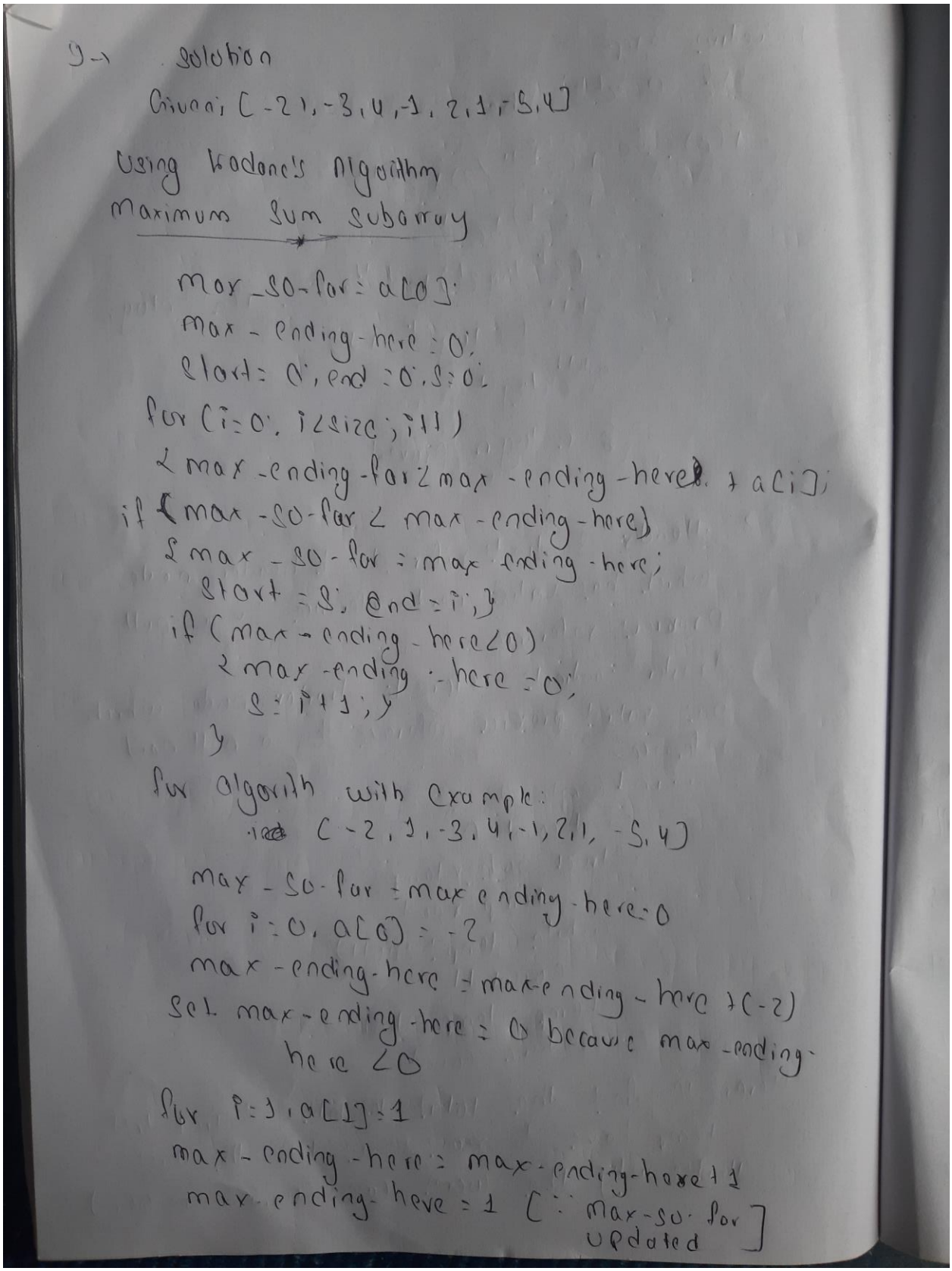
$= n \log n$ proved

2. -> Header sentinels refers to a header node which has valid next reference by a null previous reference.

Trailer sentinels refers to trailer node which has valid previous reference by a null next reference.

```
int length()
    int count = 0
    struct node *temp
        temp = root
    while (temp != null)
        count ++
        temp = temp->link
        return count
```

Here, it find the total length of link list temp have to move till the last that is why the worst-case scenario is O(n)



9→ Solution

Given: [-2, -3, 4, -1, 2, 1, -5, 4]

Using Kadane's Algorithm

Maximum Sum Subarray

```
max_so_far = a[0];
max_ending_here = 0;
start = 0, end = 0, s = 0;
for (i=0; i<size; i++)
{ max_ending_here = max_ending_here + a[i];
if (max_so_far < max_ending_here)
{ max_so_far = max_ending_here;
  start = s; end = i; }
if (max_ending_here < 0)
{ max_ending_here = 0;
  s = i+1; }
}
```

For algorith with Example:

Given: (-2, 1, -3, 4, -1, 2, 1, -5, 4)

max_so_far = max_ending_here = 0

for i = 0, a[0] = -2

max_ending_here = max_ending_here + (-2)

Set max_ending_here = 0 because max_ending_here < 0

for i = 1, a[1] = 1

max_ending_here = max_ending_here + 1

max_ending_here = 1 [∵ max_so_far updated]

for i = 2, a[2] = -3
max-ending-here = max-ending-here + (-3)
max-ending-here = 0

for i = 3, a[3] = 4
max-ending-here = max-ending-here + (4)
max-ending-here = 4
max-so-far = 4

for i = 4, a[4] = -1
max-ending-here = max-ending-here + (-1)
max-ending-here = 3

for i = 5, a[5] = 2
max-ending-here = max-ending-here + (2)
max-ending-here = 5

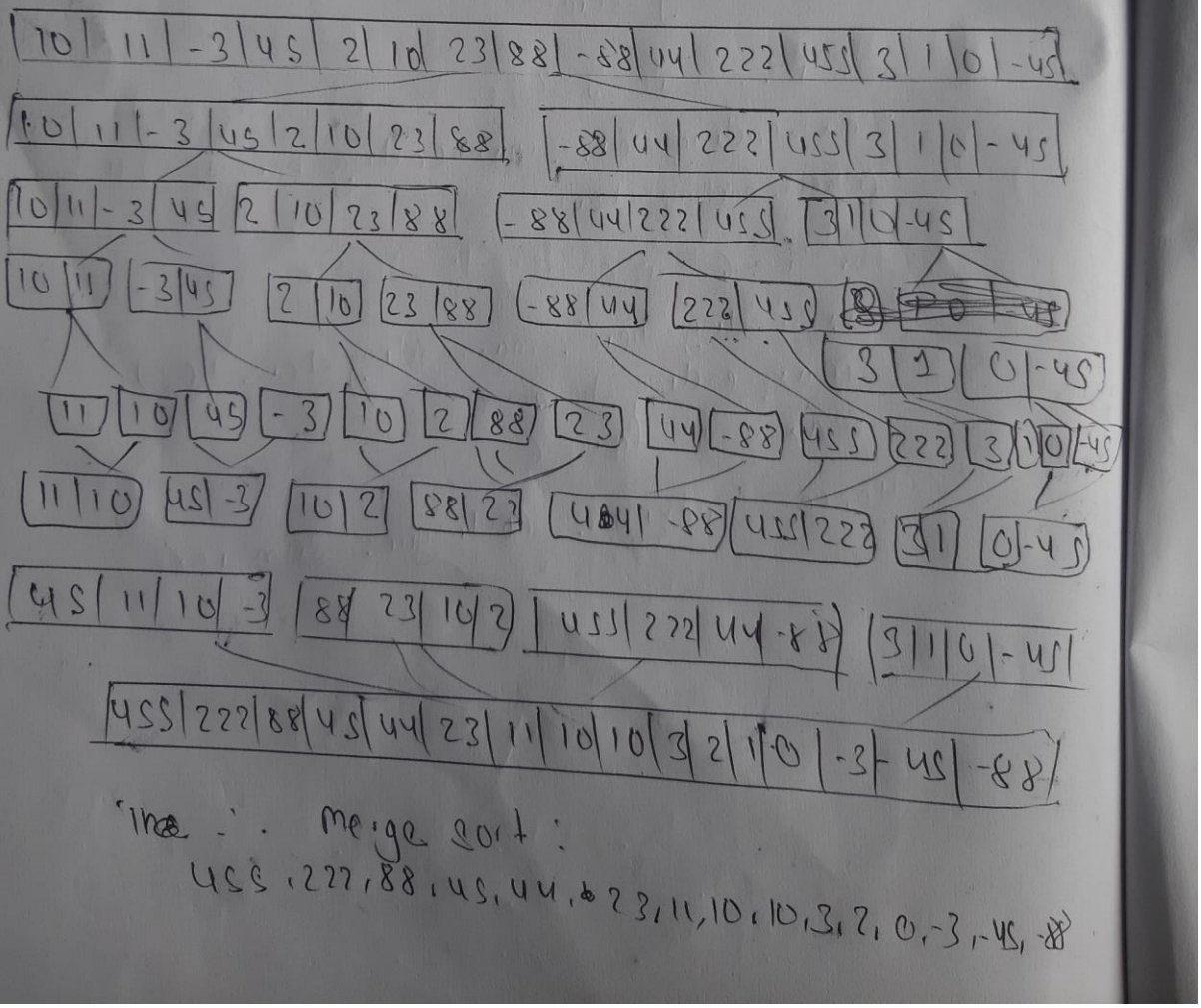
for i = 6, a[6] = 1
max-ending-here = max-ending-here + (1)
max-ending-here = 6
max-so-far = 6

Hence, maximum contiguous sum is 6.

10 → No, Quicksort is not a stable algorithm because its swipping is done accroding to ~~five~~ Pivot's position. It can be stable if two objects with equal keys are appear in the same order in sorted output as the appear in the input array to be sorted.

Merge Sort

~~10 11 3 45 2 10~~



Ans :. merge sort :

455, 222, 88, 45, 44, 23, 11, 10, 10, 3, 2, 1, 0, -3, -45, -88

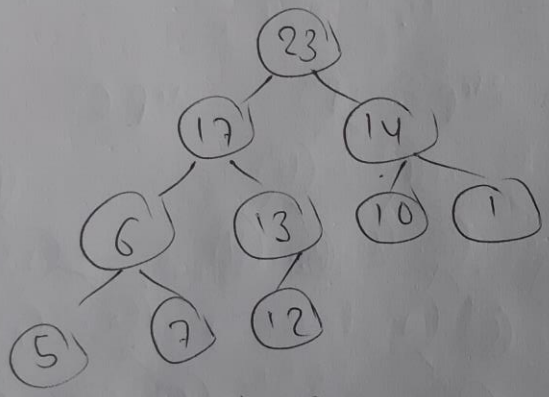
11→ The maximum and minimum numbers of elements in a heap of height are:

When the leaf node of is at height 1

maximum : $2^h - 1$

minimum : $2^h - 1$

→ Ans. the array with value <23, 17, 14, 6, 13, 10, -1, 5, 7, 12> is not a max-heap because the parent '7' is 6 in the array which violates the max-heap property.



∴ 6 < 7

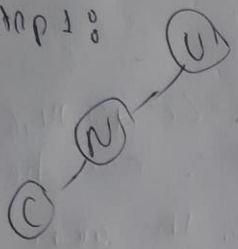
13→. Sol:

Given: UNCOPYRIGHTABLES

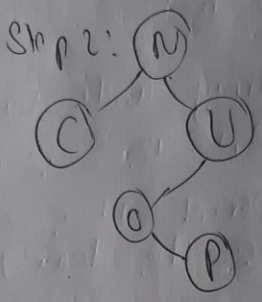
Now:

Constructing AVL tree

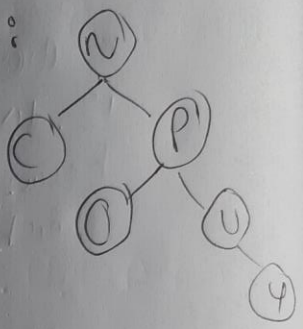
Step 1:



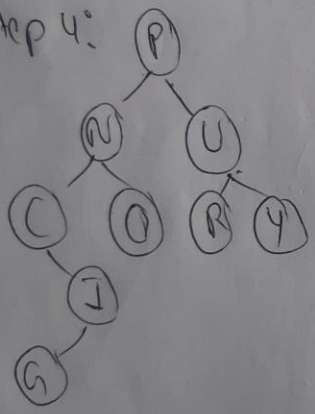
Step 2:



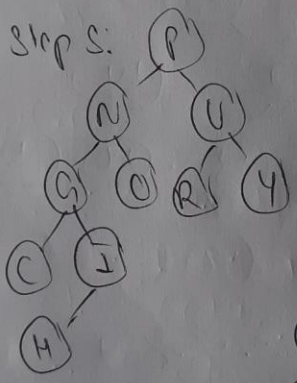
Step 3:



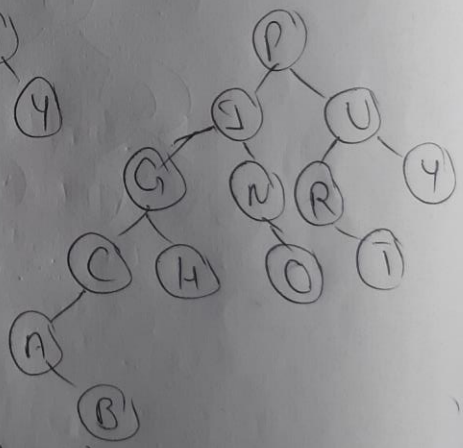
Step 4:



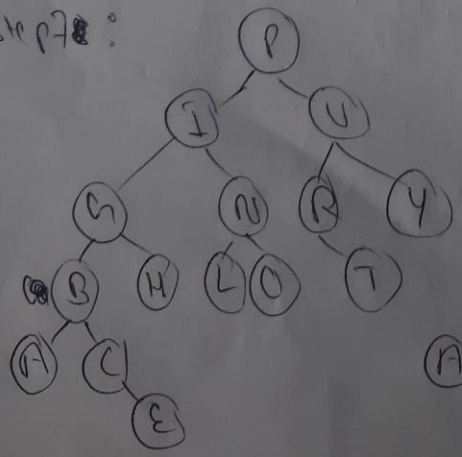
Step 5:



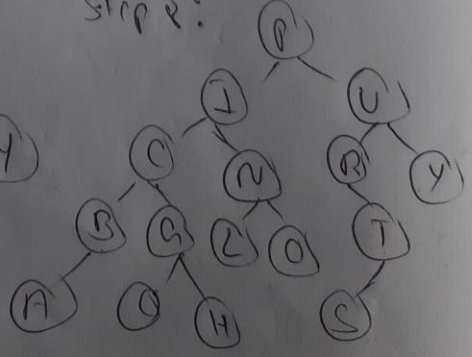
Step 6:



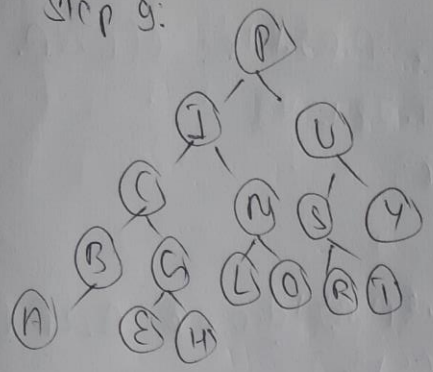
Step 7:



Step 8:



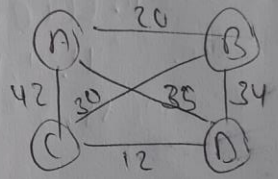
Step 9:



14 -> Solu

Given figure:

Temp



$S = \{A\}$ which is last city.

The 3 possible ways to get A are:

$C(\{B\}, \{A\}) = \min[C(A, \{\}) + d_{BA}] = 0 + 20 = 20$

$C(\{C\}, \{A\}) = \min[C(A, \{\}) + d_{CA}] = 0 + 42 = 42$

$C(\{D\}, \{A\}) = \min[C(A, \{\}) + d_{DA}] = 0 + 35 = 35$

$S = \{A, B\}, \{A, C\}, \{A, D\}$

$C(C, \{A, B\}) = \min[C(B, \{A\}) + d_{CB}] = 20 + 30 = 50$

$C(D, \{A, B\}) = \min[C(B, \{A\}) + d_{DB}] = 20 + 34 = 54$

$C(\{B\}, \{A, C\}) = \min[C(C, \{A\}) + d_{BC}] = 42 + 30 = 72$

$C(\{D\}, \{A, C\}) = \min[C(C, \{A\}) + d_{DC}] = 42 + 12 = 54$

$C(\{B\}, \{A, D\}) = \min[C(D, \{A\}) + d_{BD}] = 35 + 34 = 69$

$C(\{C\}, \{A, D\}) = \min[C(D, \{A\}) + d_{CD}] = 35 + 12 = 47$

$S = \{C, B, A\}, \{D, B, A\}, \{D, C, A\}$

$C(D,\{C,B,A\}) = \min[C(C,\{B,A\}) + d_{DC}, C(B,\{A,C\}) + d_{DB}]$

$= \min[50 + 12, 72 + 34]$

$= \min[62, 106]$

$= 62$

$C(C,\{D,B,A\}) = \min[C(D,\{B,A\}) + d_{CD}, C(B,\{A,D\}) + d_{CB}]$

$= \min[54 + 12, 69 + 30]$

$= \min[66, 99]$

$= 66$

$C(B,\{D,C,A\}) = \min[C(D,\{A,C\}) + d_{BD}, C(C,\{A,D\}) + d_{BC}]$

$= \min[54 + 34, 42 + 30]$

$= \min[88, 72]$

$= 72$

$S = \{D,C,B,A\}$

$C(A,S) = \min[C(D,\{C,B,A\}) + d_{AD}, C(C,\{D,B,A\}) + d_{AC}, C(B,\{D,C,A\}) + d_{AB}]$

$= [62 + 35, 66 + 42, 72 + 20]$

$= \min[97, 108, 92]$

$= 97$

∴ Required path ABCDA
ACDBA

```
Is ->. Electricity(data)
  if (Q. isEmpty)
    Q. Enqueue(data)
    Q. front = data;
  else
    if (Q.length != array.length-1)
    if(data == Q.front)
      dequeue(Q);
    if (Q.length == array.length-1)
      dequeue(Q);
      else Enqueue(data);
    else
      dequeue(data);
    return

Enqueue(Q, x)
  Q.[Q.back] = x
  if (Q.back == Q.length)
    Q.back = 0
    else Q.back = Q.back+1

  dequeue(Q)
    x = Q[Q.front]
    if (Q.front == Q.length)
      Q.front == 0
    else Q.front = Q.front+1
      return x.

  OverFlow()
    if array.length == queue.length
      return true
      else false
: Time complexity is O(1)
```

16 -> Solution.

Given hash function $h(n) = n$

the order of array is

0	1	2	3	4	5	6	7	8
9	18		12	13	14	4	21	

for linear provision

$h(n) = n \% 9$

for A - 9, 14, 4, 18, 12, 3, 21

key (n)	Position ($h(n) = n \% 9$)
9	$9 \% 9 = 0$
14	$14 \% 9 = 5$
4	$4 \% 9 = 4$
18	$18 \% 9 = 0$
12	$12 \% 9 = 3$
3	$3 \% 9 = 3$
21	$21 \% 9 = 3$

0	1	2	3	4	5	6	7	8
9	18		12	4	14	3	21	

Here, in 4 index we have 4, but in array we have 3. So, it is not suitable

B - 12, 3, 14, 18, 4, 9, 21

key (n)	Position ($h(x) = x \% 9$)
12	$12 \% 9 = 3$
3	$3 \% 9 = 3$
14	$14 \% 9 = 5$
18	$18 \% 9 = 0$
4	$4 \% 9 = 4$
9	$9 \% 9 = 0$
21	$21 \% 9 = 3$

0	1	2	3	4	5	6	7	8
18	9		12	3	14	4	21	

Here, In 0 index we have 18, but in array we have 9. so, it also can't be the possible one.

C - 12, 14, 3, 9, 4, 18, 21

Key(n)	Position (h(n) : n%9)
12	12%9=3
14	14%9=5
3	3%9=3
9	9%9=0
4	4%9=4
18	18%9=0
21	21%9=3

0	1	2	3	4	5	6	7	8
9	18		12	3	14	4	21	

It is one of the possible answer

D - 9, 12, 14, 3, 4, 21, 18

Same as above 'C' in the index 6 there is 21 and the original array is also 21 it is possible answer

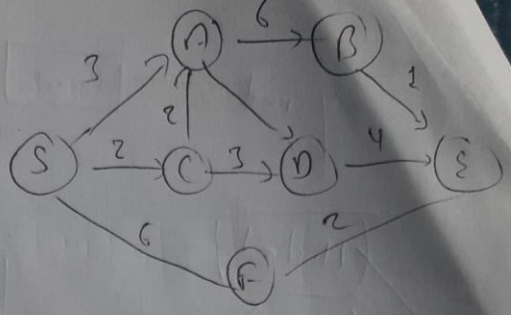
E - ~~Same as~~ 12, 9, 18, 3, 14, 21, 4

Same as above, in the index 6 there is 21. but in our ~~org~~ original array it is 4 so, it is not possible answer.

∴ the possible answer is C and D.

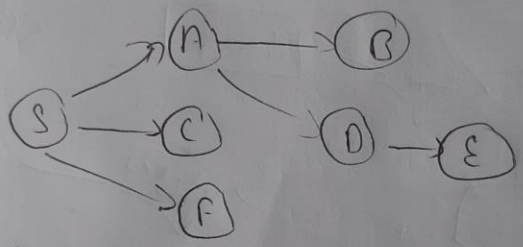
17 → Soln

Given,



In Dijkstra's algorithm, it can visit following vertices in order.
S, C, A, D, F, E }.

So, the parent of each node should be like this:



Dijkstra algorithm only removes from the priority queue |v| times. Removal takes of $O(\log |v|)$ time for a total of $O(|v| \log(v))$ time for all vertex removals.

For the shortest path to vertices.

Vertices	S	A	B	C	D	E	F
S	0_S	3_S	∞_S	2_S	∞_S	∞_S	6_S
A	0_S	3_S	∞_S	2_S	5_P	∞_S	6_S
B	0_S	3_S	9_A	2_S	4_A	∞_S	6_S
C	0_S	3_S	9_A	2_S	4_A	8_D	6_S
D	0_S	3_S	9_A	2_S	4_A	8_D	6_S
E	0_S	3_S	9_A	2_S	4_A	8_D	6_S
F	0_S	3_S	9_A	2_S	4_A	8_D	6_S

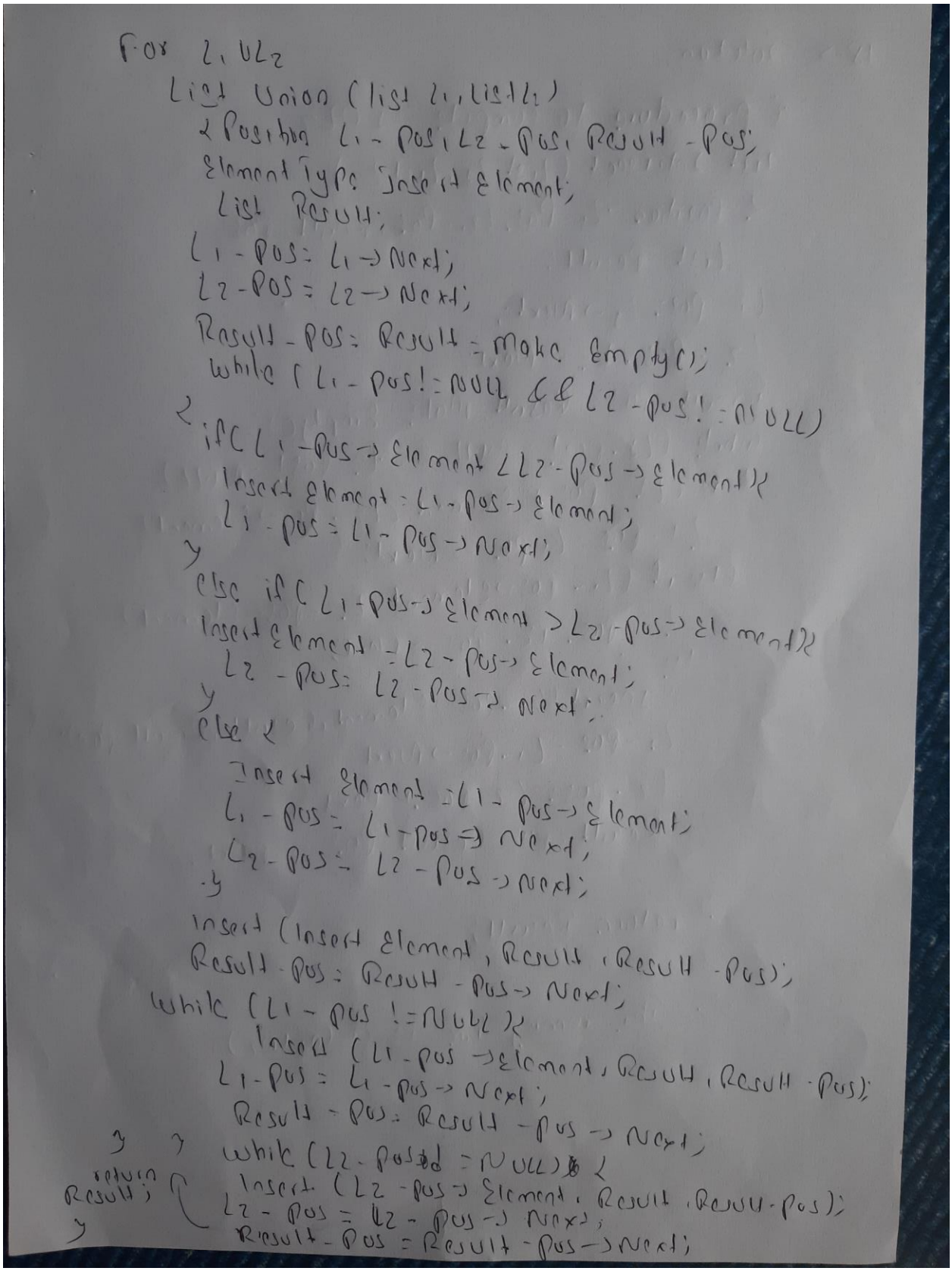
∴ Path : S, A, D, E

18-> Solution

a Procedure to compute $L_1 \cap L_2$

```
List Intersect (List L1, List L2)
{ Position L1_Pos, L2_Pos, Result_Pos;
  List Result;
L1_Pos = L1 -> Next;
L2_Pos = L2 -> Next;
Result_Pos = Result = MakeEmpty();
while (L1_Pos != NULL && L2_Pos != NULL)
{ if (L1_Pos -> Element < L2_Pos -> Element)
    L1_Pos = L1_Pos -> Next;
  else if (L1_Pos -> Element > L2_Pos -> Element)
    L2_Pos = L2_Pos -> Next;
  else
  { Insert(L1_Pos -> Element, Result, Result_Pos);
    L1_Pos = L1_Pos -> Next;
    L2_Pos = L2_Pos -> Next;
    Result_Pos = Result_Pos -> Next;
  }
}
return Result;
}
```

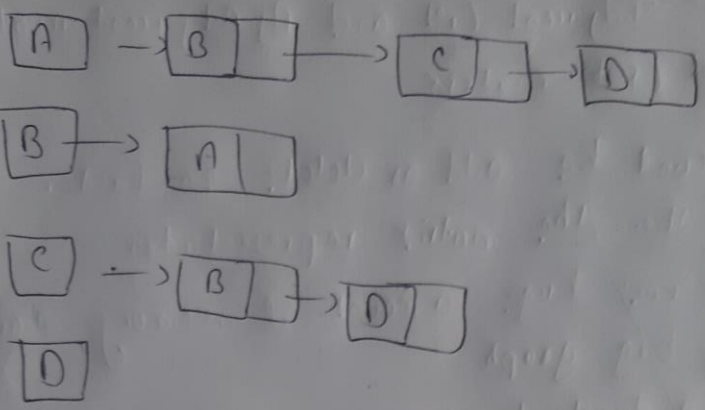
∴ the running time is $O(n_1 + n_2)$.



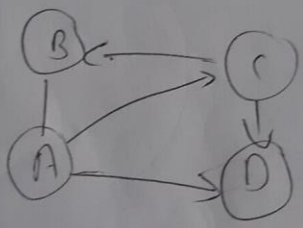
```
For L1 UL2
   List Union (List L1, List L2)
   {Position L1_pos, L2_pos, Result_pos;
    ElementType Insert Element;
    List Result;
    L1_pos = L1->Next;
    L2_pos = L2->Next;
    Result_pos = Result = MakeEmpty();
    while ( L1_pos != NULL && L2_pos != NULL)
    {
    if(L1_pos->Element < L2_pos->Element){
      Insert Element = L1_pos->Element;
      L1_pos = L1_pos->Next;
    }
    else if( L1_pos->Element > L2_pos->Element){
    Insert Element = L2_pos->Element;
      L2_pos = L2_pos->Next;
    }
    else {
       Insert Element = L1_pos->Element;
       L1_pos = L1_pos->Next;
       L2_pos = L2_pos->Next;
    }
    Insert (Insert Element, Result, Result_pos);
    Result_pos = Result_pos->Next;
    while (L1_pos != NULL){
        Insert (L1_pos->Element, Result, Result_pos);
        L1_pos = L1_pos->Next;
        Result_pos = Result_pos->Next;
    } } while (L2_pos != NULL){
        Insert (L2_pos->Element, Result, Result_pos);
        L2_pos = L2_pos->Next;
        Result_pos = Result_pos->Next;
    return Result;
    }
```

1) → Solution

Given:



a → Directed graph



b) Adjacency Matrix

	A	B	C	D
A	0	1	1	1
B	1	0	0	0
C	0	1	0	1
D	0	0	0	0

Edges: {(A, B), (A, C), (A, D), (B, A), (C, B), (C, D)}

c) - Adjacency matrix

Pros - Adjacency matrix is fast to check whether edge between two nodes are exists or not.

- Add or delete an edge can be done in O(1) time.

Cons -

- Adjacency matrix consumes a lot of memory for storing big graph.
- The effort for adding or deleting nodes requires huge efforts
- It redundant the information for undirected graph

Adjacency List

Pros -

- Adjacency list allows efficients space to store graph.
- The new edges can be added in O(1) time.

Cons

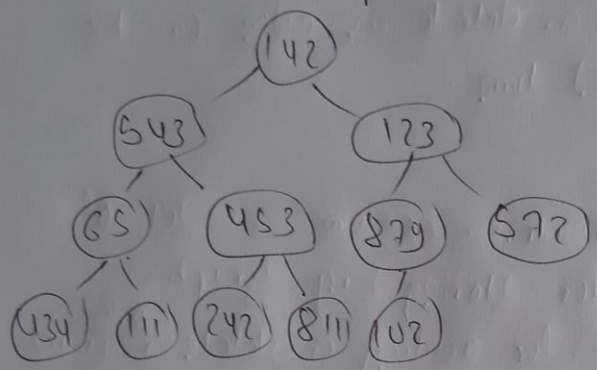
- It does not allow to make an efficient implementation if dynamically change of vertices number is required.
- Adding or deleting edge to it is not hard for adjacency matrix

20-> The running time of heapsort for presorted input is O(nlogn).

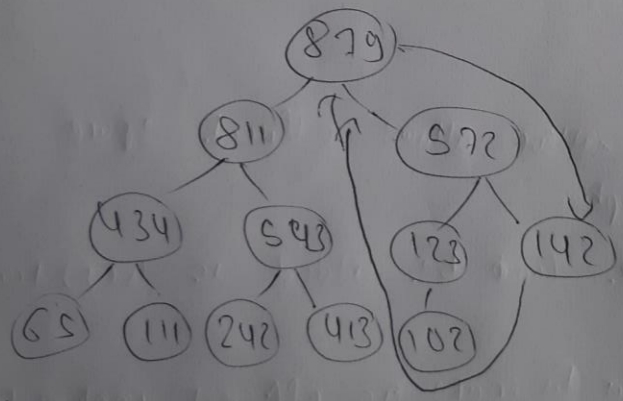
Given data:

142, 543, 123, 65, 453, 879, 572, 434, 111, 242, 811, 102

Step 1: Build the heap



Now, turning into maximum heap.



Step 2: