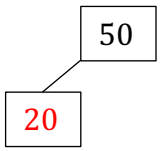
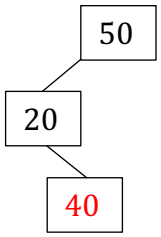
Q1a)

50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25

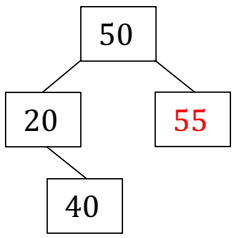
50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



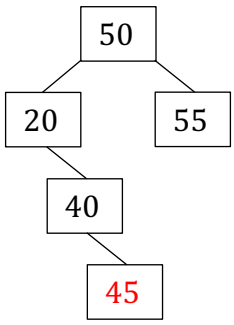
50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



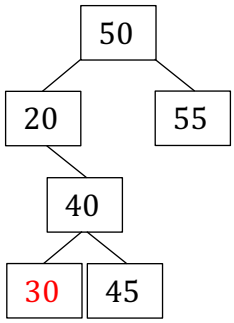
50, 20, 40, 55, 45, 30 10, 15, 35, 60, 5, 25



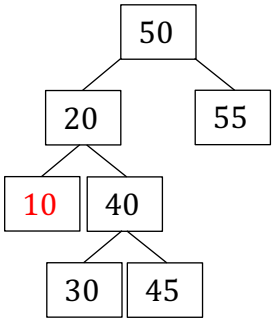
50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



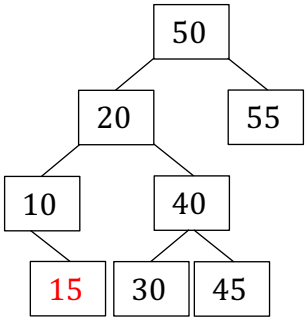
50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



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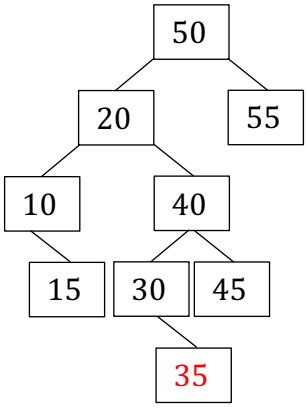
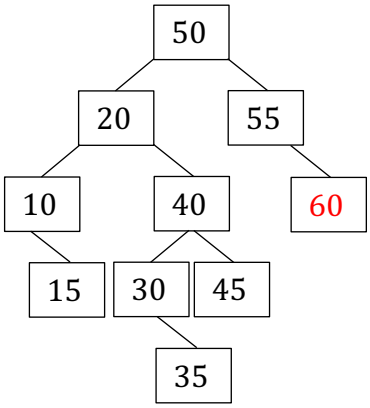
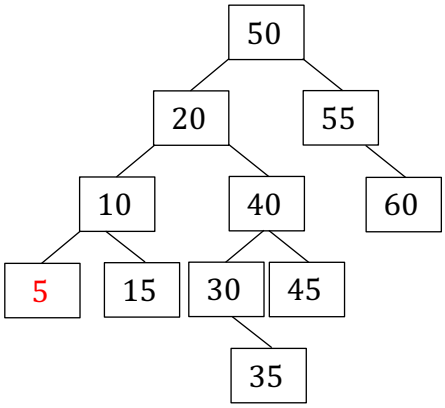
50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25



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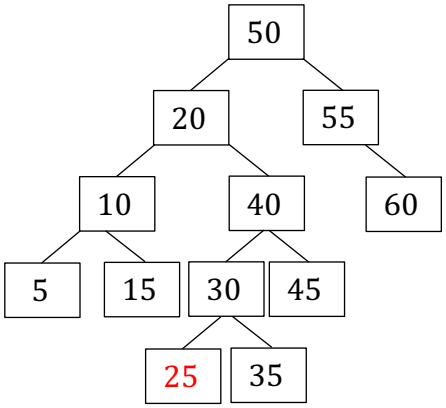
50, 20, 40, 55, 45, 30, 10, 15, 35, 60, 5, 25

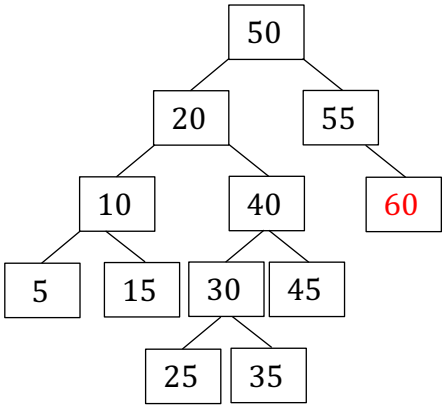


Q1b)

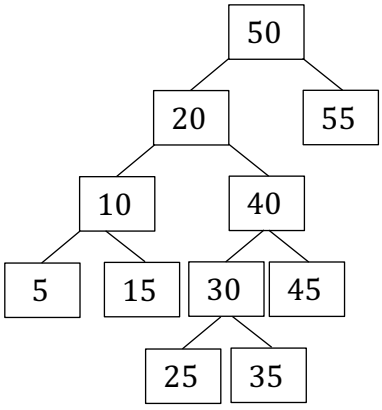
Pre-order: 50, 20, 10, 5, 15, 40, 30, 25, 35, 45, 55, 60
In-order: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60
Post-order: 5, 15, 10, 25, 35, 30, 45, 40, 20, 60, 55, 50

Q1c)

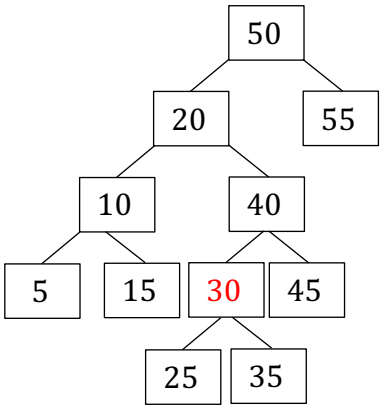
Delete 60



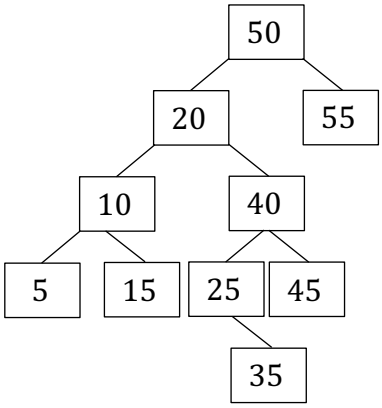
Leaf Node, directly delete



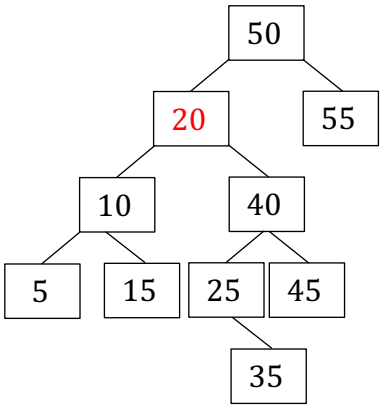
Delete 30



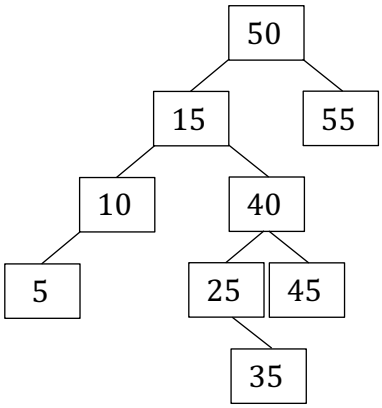
Internal Node, replace by maximum in left sub tree



Delete 20



Internal Node, replace by maximum in left sub tree

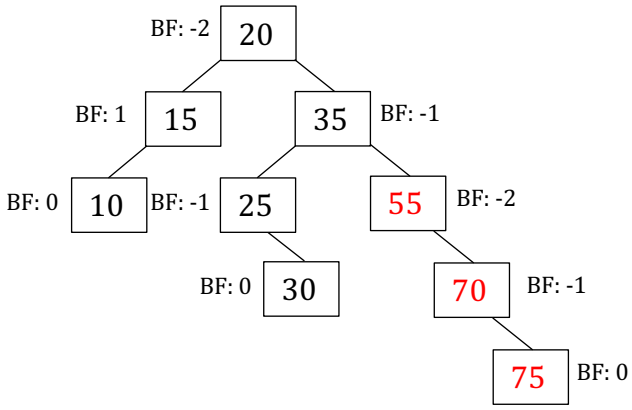


Q1d)

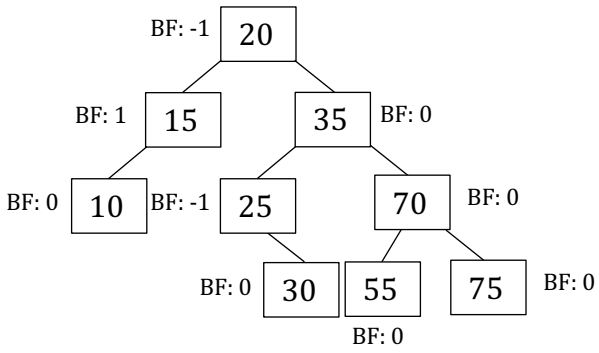
Pre-order:	50, 15, 10, 5, 40, 25, 35, 45, 55
In-order:	5, 10, 15, 25, 35, 40, 45, 50, 55
Post-order:	5, 10, 35, 25, 45, 40, 15, 55, 50

2a)

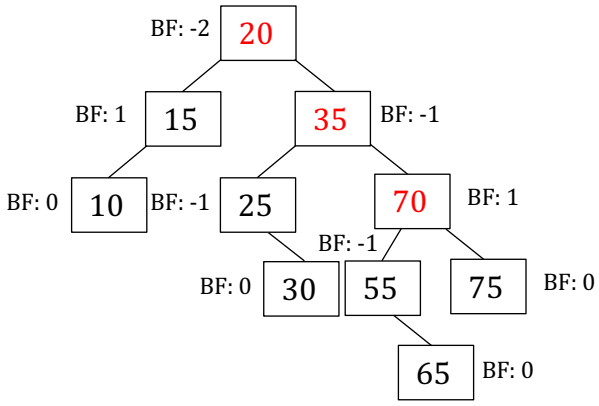
Add 75



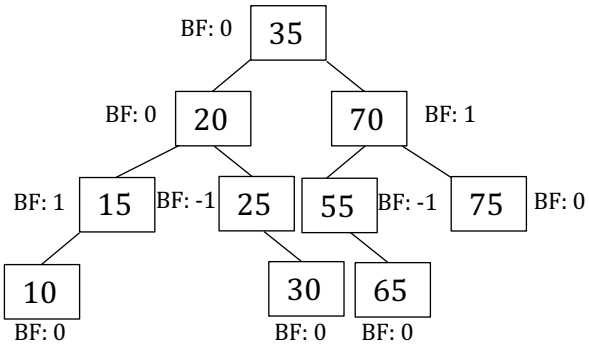
Refactor & Restore AVL property



Add 65

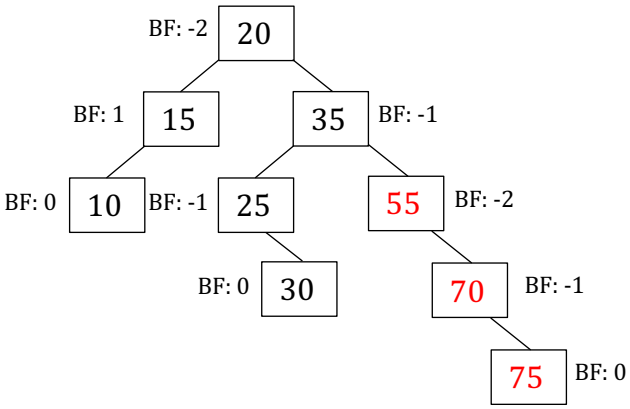


Refactor & Restore AVL Property

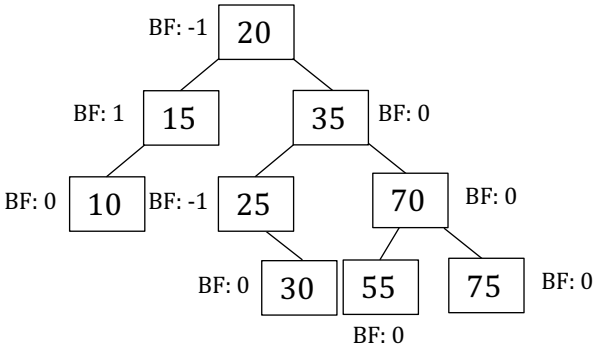


2b)

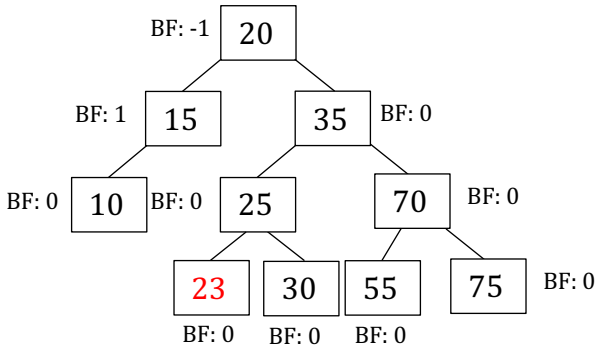
Add 75



Refactor & Restore AVL property

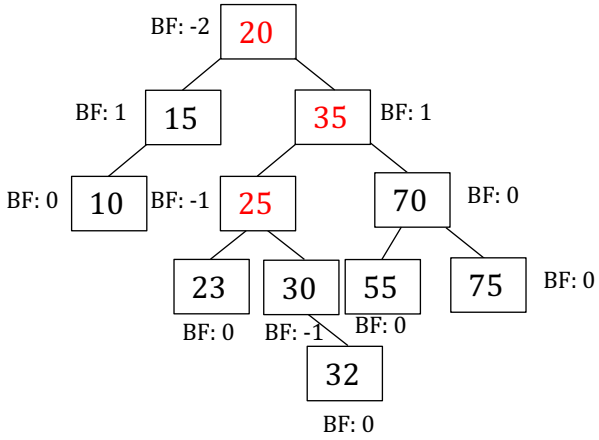


Add 23

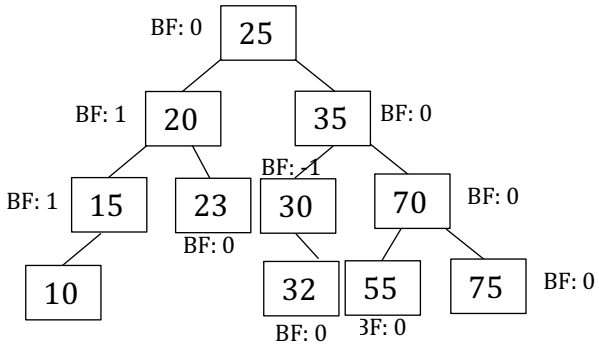


No need to Refactor & Restore AVL Property

Add 32

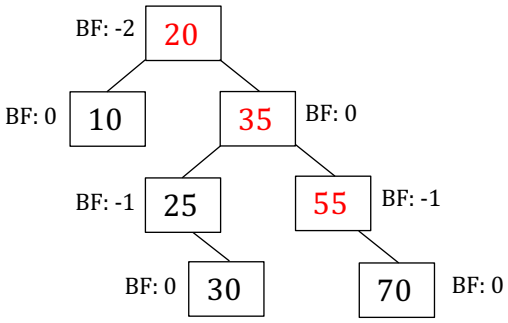


Add 32

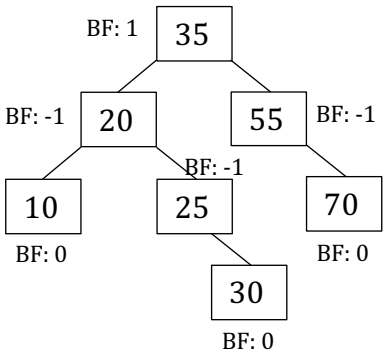


2c)

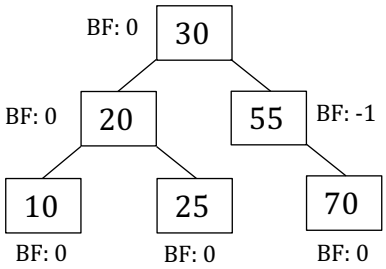
Remove 15



Refactor & Restore AVL property



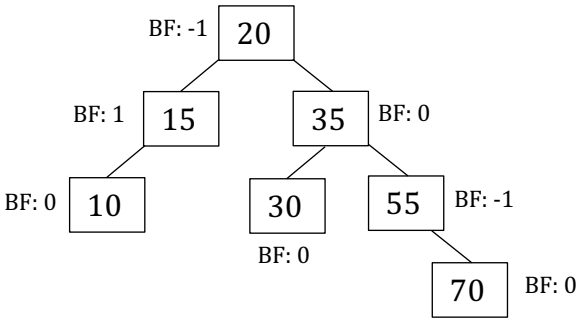
Remove 35
Replaced by largest value in left sub tree
No need to Refactor & Restore AVL property



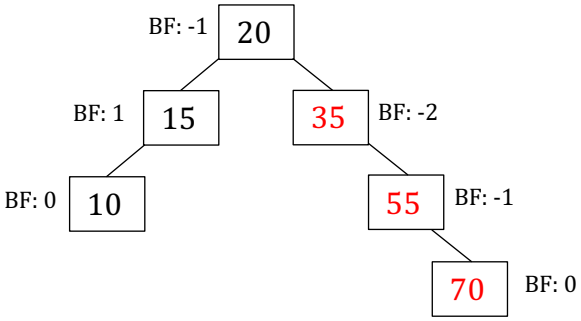
2c)

Remove 25

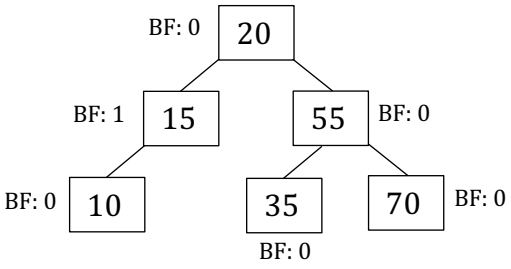
No need to Refactor and Restore AVL property



Remove 30



Refactor and Restore AVL property

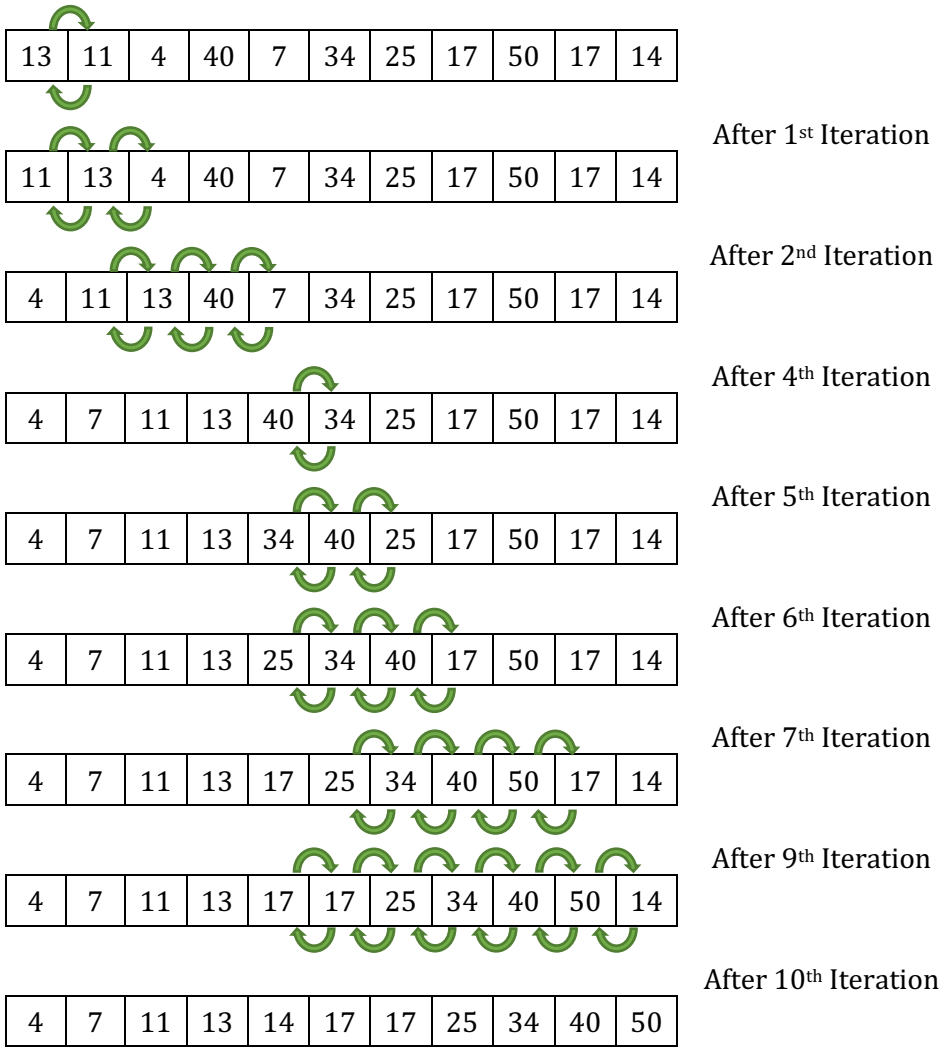


Q3 (a) Insertion sort

Note: The array is displayed only after iterations where changes are made to the array

```
1   def insertionSort(arr):
2       for i in range(1, len(arr)):
3           key = arr[i]
4           j = i-1
5           while j >= 0 and key < arr[j]:
6               arr[j + 1] = arr[j]
7               j = j - 1
8           arr[j + 1] = key
```

Note: This is the algorithm which was hand traced.
NOT COMPILED AND RUN



Total swaps made: 22 swaps

: One Swap

Assignments:	Line 3, Line 4, Line 6, Line 7, Line 8
Comparisions:	Line 5
Total Assignemnts:	74
Total Comparisions:	32
Assignments + Comparisions:	106

Q3 (b) Selection sort

```
1       def selectionSort(arr):
2               for i in range(len(arr)):
3                       minVal = i
4                       for j in range(i+1, len(arr)):
5                               if arr[minVal] > arr[j]:
6                               minVal = j
7                       arr[i], arr[minVal] = arr[minVal], arr[i]
```

Note: This is the algorithm which was hand traced.
NOT COMPILED AND RUN

13	11	4	40	7	34	25	17	50	17	14

After 1st Iteration

4	11	13	40	7	34	25	17	50	17	14

After 2nd Iteration

4	7	13	40	11	34	25	17	50	17	14

After 3rd Iteration

4	7	11	40	13	34	25	17	50	17	14

After 4th Iteration

4	7	11	13	40	34	25	17	50	17	14

After 5th Iteration

4	7	11	13	14	34	25	17	50	17	40

After 6th Iteration

4	7	11	13	14	17	25	34	50	17	40

After 7th Iteration

4	7	11	13	14	17	17	34	50	25	40

After 8th Iteration

4	7	11	13	14	17	17	25	50	34	40

After 9th Iteration

4	7	11	13	14	17	17	25	34	50	40

After 10th Iteration

4	7	11	13	14	17	17	25	34	40	50

Total swaps made: 10 swaps

Assignments:	Line 3, Line 6, Line 7
Comparisions:	Line 5
Total Assignemnts:	37
Total Comparisions:	55
Assignments + Comparisions:	92

Q3 (c) Heap sort

Note: The heapify method creates a max heap and stores it in arr, thereby rearragning the elements

```
1   def heapSort(arr):
2       n = len(arr)
3
4       for i in range(n // 2 - 1, -1, -1):
5           heapify(arr, n, i)
6
7       for i in range(n-1, 0, -1):
8           arr[i], arr[0] = arr[0], arr[i]
9           heapify(arr, i, 0)
10
11  def heapify(arr, n, i):
12      largest = i
13      l = 2 * i + 1
14      r = 2 * i + 2
15
16      if l < n and arr[i] < arr[l]:
17          largest = l
18
19      if r < n and arr[largest] < arr[r]:
20          largest = r
21
22      if largest != i:
23          arr[i],arr[largest] = arr[largest],arr[i]
24          heapify(arr, n, largest)
```

Note: This is the algorithm which was hand traced.
NOT COMPILED AND RUN

13	11	4	40	7	34	25	17	50	17	14

Initial Max-Heap formed 8 swaps performed

50	40	34	17	17	4	25	13	11	7	14

After 1st Iteration

Swap 1 swap performed

14	40	34	17	17	4	25	13	11	7	50

Reform max-heap 2 swaps performed

40	17	34	14	17	4	25	13	11	7	50

After 2nd Iteration

Swap 1 swap performed

7	17	34	14	17	4	25	13	11	40	50

Reform max-heap 2 swaps performed

34	17	25	14	17	4	7	13	11	40	50

After 3rd Iteration

Swap 1 swap performed

11	17	25	14	17	4	7	13	34	40	50

Reform max-heap 1 swap performed

25	17	11	14	17	4	7	13	34	40	50

After 4th Iteration

Swap 1 swap performed

13	17	11	14	17	4	7	25	34	40	50

Reform max-heap 2 swaps performed

17	17	11	14	13	4	7	25	34	40	50

After 5th Iteration

Swap 1 swap performed

7	17	11	14	13	4	17	25	34	40	50

Reform max-heap 2 swaps performed

17	14	11	7	13	4	17	25	34	40	50

After 6th Iteration

Swap 1 swap performed

4	14	11	7	13	17	17	25	34	40	50

Reform max-heap 2 swaps performed

14	13	11	7	4	17	17	25	34	40	50

After 7th Iteration

Swap 1 swap performed

4	13	11	7	14	17	17	25	34	40	50

Reform max-heap 2 swaps performed

13	7	11	4	14	17	17	25	34	40	50

After 8th Iteration

Swap 1 swap performed

4	7	11	13	14	17	17	25	34	40	50

Reform max-heap 1 swap performed

11	7	4	13	14	17	17	25	34	40	50

After 9th Iteration

Swap 1 swap performed

4	7	11	13	14	17	17	25	34	40	50

Reform max-heap 1 swap performed

7	4	11	13	14	17	17	25	34	40	50

After 10th Iteration

Swap 1 swap performed

4	7	11	13	14	17	17	25	34	40	50

Reform max-heap 0 swap performed

4	7	11	13	14	17	17	25	34	40	50

Total swaps made: 33 swaps

Assignments:	Line 2, Line 8, Line 12, Line 13, Line 14, Line 17, Line 20, Line 23
Comparisions:	Line 16, Line 19, Line 22
Total Assignemnts:	177
Total Comparisions:	114
Assignments + Comparisions:	291

Q3) (d) Merge sort

[13] [11] [4] [40] [7] [34] [25] [17] [50] [17] [14]
[11 13] [4 40] [7 34] [17 25] [17 50] [14]
[4 11 13 40] [7 17 25 34] [14 17 50]
[4 7 11 13 17 25 34 40] [14 17 50]
[4 7 11 13 14 17 17 25 34 50]

Algorithm followed:

1 Repeat Until: Array not sorted
2 Select pairs of arrays
3 Repeat Until: No element left in list
4 Find smallest element by comparision
5 Merge smallest element into array (Assignment)
6 Mark smallest element as added

Example:

Line 2: Select pairs of arrays
[11 13] [4 40]
Loop start
Line 4: Find smallest element by comparision (Ignore added elements)
[11 13] [4 40]
Line 5: Merge smallest element into array
[4 11 13] [40]
Line 6: Mark smallest element as added
[4 11 13] [40]
Loop back and repeat process

This process repeats until the whole array is sorted

Number of comparisions
=

$$\sum_{i=1}^{2} i + \sum_{i=1}^{4} i + \sum_{i=1}^{8} i + \sum_{i=1}^{11} i = 115$$

Total Comparisions:	115
Total Assignments:	40
Assignments + Comparisions:	155

Note: This is the algorithm which was hand traced.
NOT COMPILED AND RUN

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Q3 (e) Quick Sort

Algorithm used:

```
1       def quickSort(arr, l, r):
2           if( l>= r):
3               return

4           p = partition(arr, l, r)
5           quickSort(arr, l, p-1)
6           quickSort(arr, p+1, r)
```

```
7       def partition(arr, l, r):
8           pivot = arr[r]
9           i = l-1
10          for j in range(l, r):
11              if arr[j] < pivot:
12                  i += 1
13                  swap(arr[i], arr[j])
14                  swap(arr[i+1], arr[r])
15          return(i+1)
```

Original List

13	11	4	40	7	34	25	17	50	17	14

1st Recursive Call – quickSort(arr, 0, len(arr)-1)

l = 0, r = 10

13	11	4	40	7	34	25	17	50	17	14

Pivot = 14 at Index 10

Array output after partition call:

13	11	4	7	14	34	25	17	50	17	40

After parition call (p = 4)

2nd Recursive Call – quickSort(arr, 0, 3)

l = 0, r = 3

13	11	4	7	14	34	25	17	50	17	40

Pivot = 7 at Index 3

Array output after partition call:

4	7	13	11	14	34	25	17	50	17	40

After parition call (p = 1)

3rd Recursive Call – quickSort(arr, 0, 0)

Base Case – No changes to array

4th Recursive Call – quickSort(arr, 2, 3)

l = 0, r = 3

4	7	13	11	14	34	25	17	50	17	40

Pivot = 11 at Index 3

Array output after partition call:

4	7	11	13	14	34	25	17	50	17	40

After parition call (p = 2)

5th Recursive Call – quickSort(arr, 2, 1)

Base Case – No changes to array

6th Recursive Call – quickSort(arr, 3, 3)

Base Case – No changes to array

7th Recursive Call – quickSort(arr, 5, 10)

l = 5, r = 10

4	7	11	13	14	34	25	17	50	17	40

Pivot = 40 at Index 10

Array output after partition call:

4	7	11	13	14	34	25	17	17	40	50

After parition call (p = 9)

8th Recursive Call – quickSort(arr, 5, 8)

l = 5, r = 8

4	7	11	13	14	34	25	17	17	40	50

Pivot = 17 at Index 8

Array output after partition call:

4	7	11	13	14	17	25	17	34	40	50

After parition call (p = 5)

9th Recursive Call – quickSort(arr, 5, 4)

Base Case – No changes to array

10th Recursive Call – quickSort(arr, 6, 8)

l = 6, r = 8

4	7	11	13	14	17	25	17	34	40	50

Pivot = 34 at Index 8

Array output after partition call:

4	7	11	13	14	17	25	17	34	40	50

After parition call (p = 8)

11th Recursive Call – quickSort(arr, 6, 7)

l = 6, r = 7

4	7	11	13	14	17	25	17	34	40	50

Pivot = 17 at Index 7

Array output after partition call:

4	7	11	13	14	17	17	25	34	40	50

After parition call (p = 6)

12th Recursive Call – quickSort(arr, 6, 5)

Base Case – No changes to array

13th Recursive Call – quickSort(arr, 7, 7)

Base Case – No changes to array

14th Recursive Call – quickSort(arr, 9, 8)

Base Case – No changes to array

15th Recursive Call – quickSort(arr, 10, 10)

Base Case – No changes to array

Final Sorted array

4	7	11	13	14	17	17	25	34	40	50

Assignments:	Line 4, Line 8, Line 9, Line 12, Line 13, Line 14
Comparisions:	Line 2, Line 11
Total Assignemnts:	51
Total Comparisions:	41
Assignments + Comparisions:	92

Q4) (1)

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

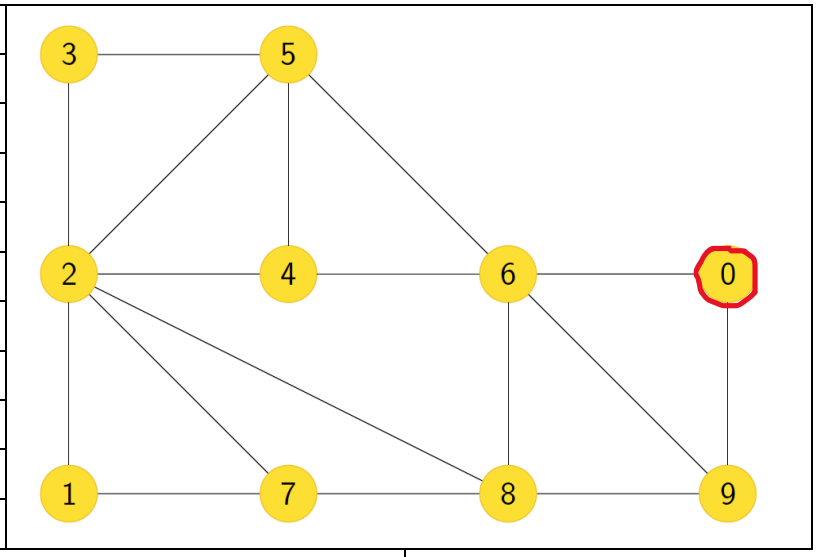
Q4) (2)

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

Q4) (3)

BFS(0)

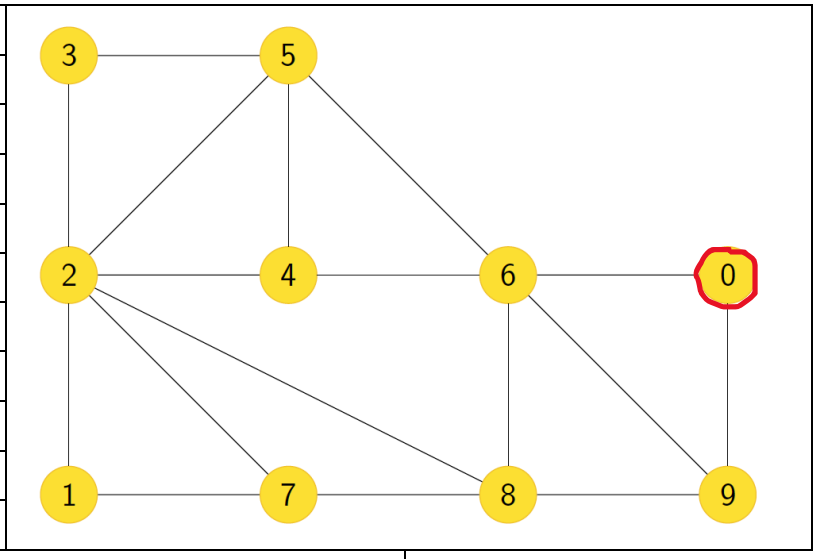
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |0|

BFS Traversal =

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |6, 9|

BFS Traversal = 0

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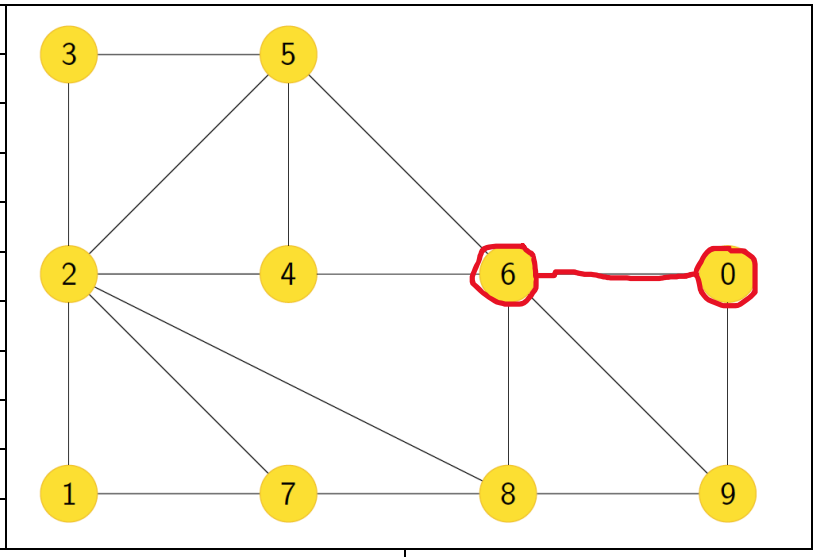
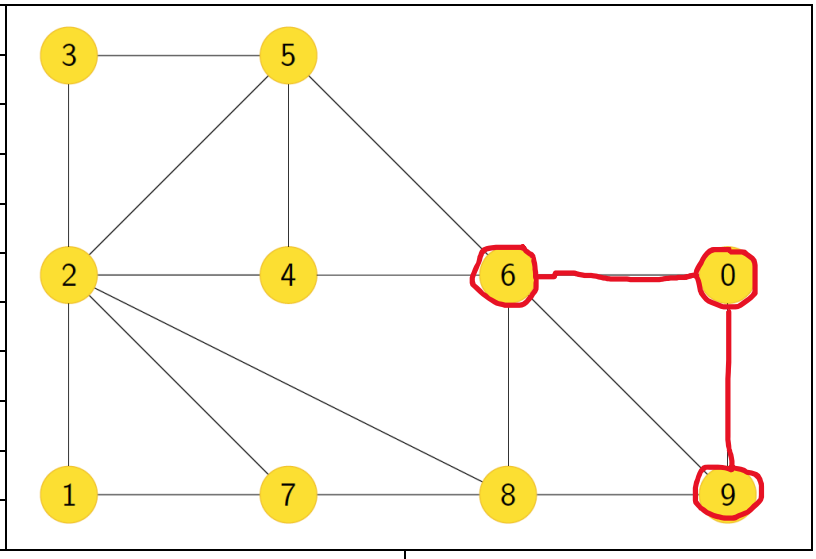
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |9, 4, 5, 8|

BFS Traversal = 0, 6

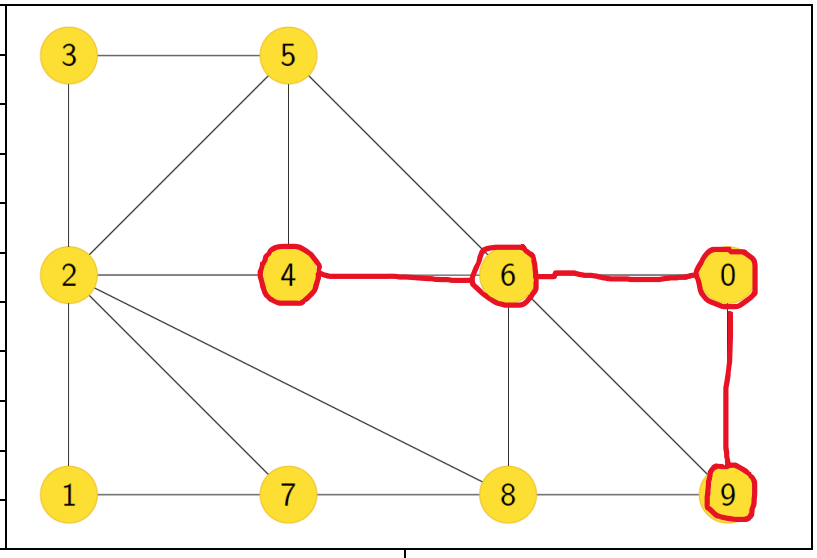
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |4, 5, 8|

BFS Traversal = 0, 6, 9

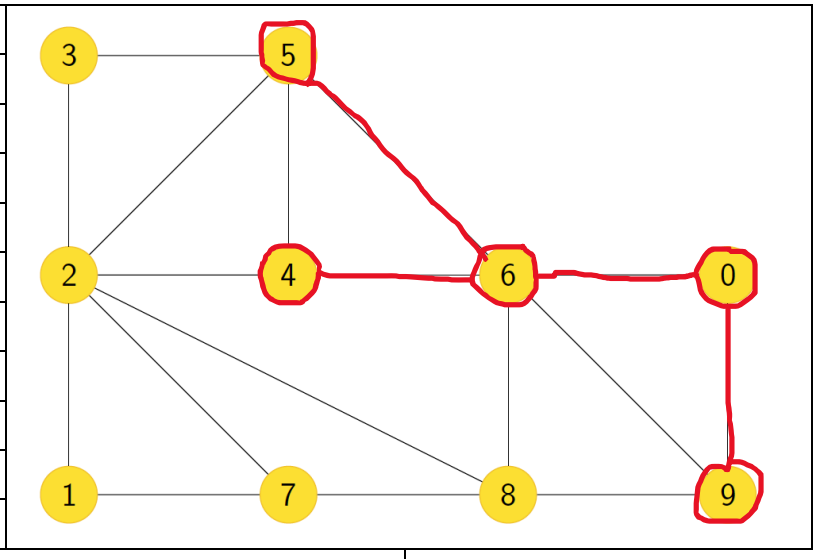
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |5, 8, 2|

BFS Traversal = 0, 6, 9, 4

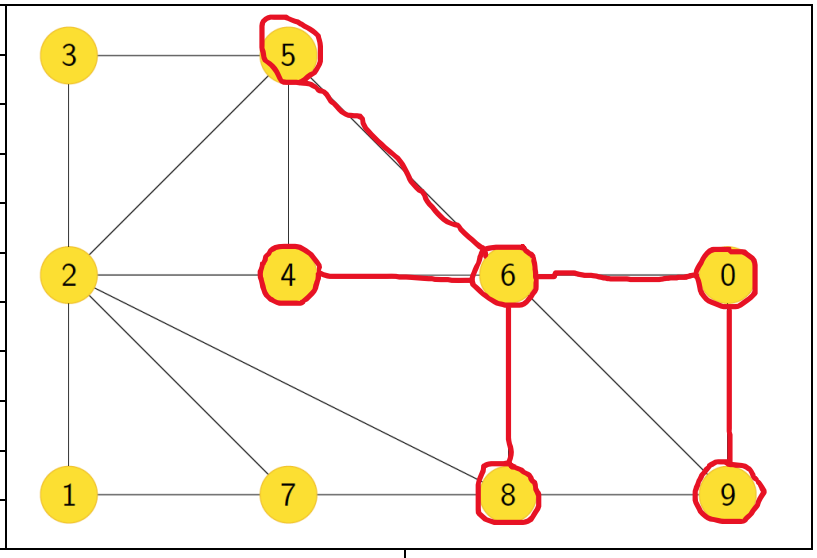
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |8, 2, 3|

BFS Traversal = 0, 6, 9, 4, 5

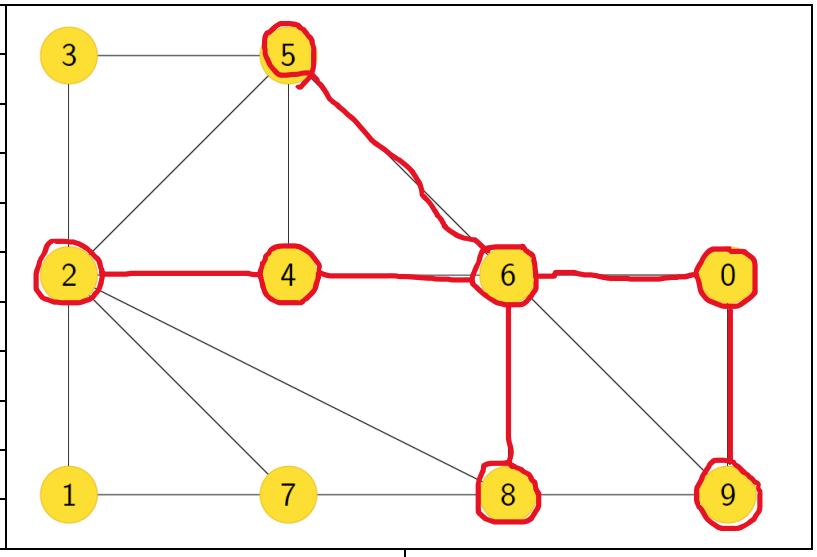
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |2, 3, 7|

BFS Traversal = 0, 6, 9, 4, 5, 8

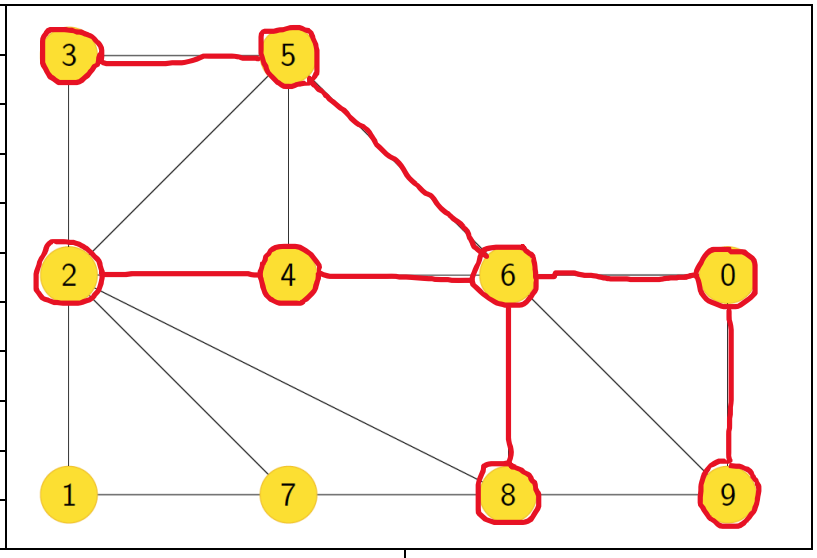
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |3, 7, 1|

BFS Traversal = 0, 6, 9, 4, 5, 8, 2

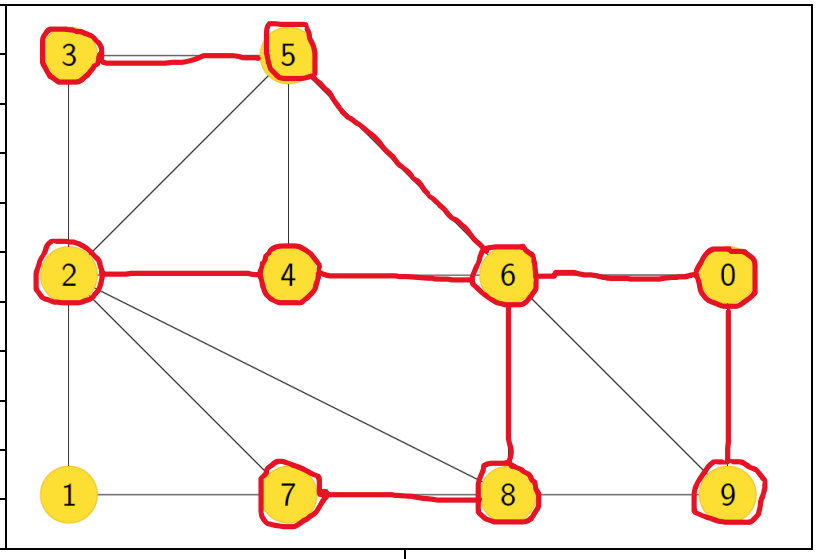
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |7, 1|

BFS Traversal = 0, 6, 9, 4, 5, 8, 2, 3

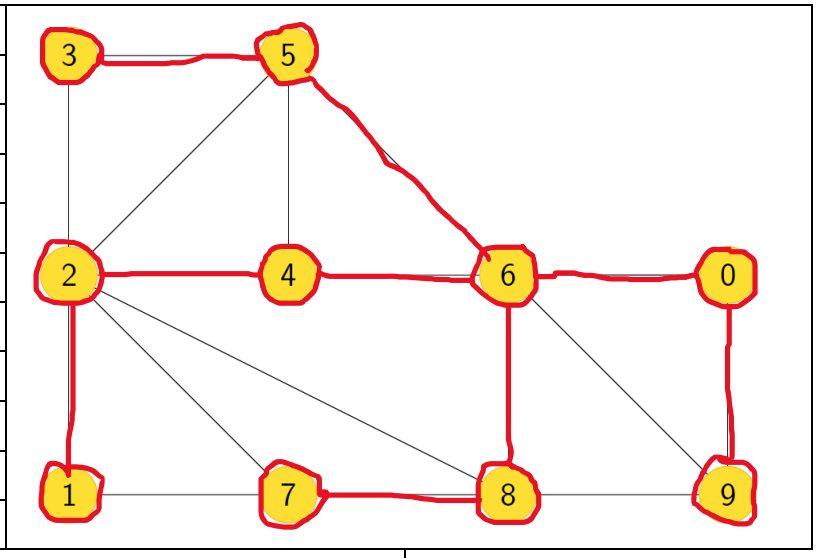
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



Queue = |1|

BFS Traversal = 0, 6, 9, 4, 5, 8, 2, 3, 7

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



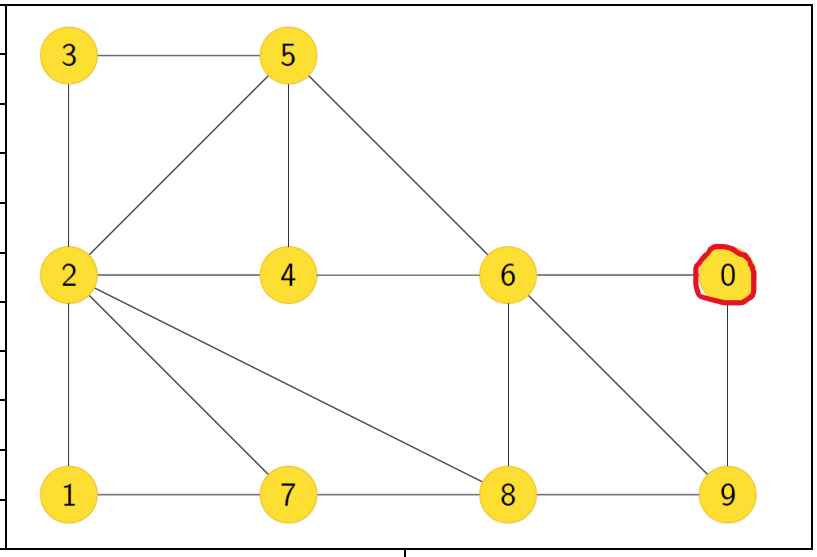
Queue = ||

BFS Traversal = 0, 6, 9, 4, 5, 8, 2, 3, 7, 1

BFS Traversal – 0, 6, 9, 4, 5, 8, 2, 3, 7, 1
Note: The tree structure is shown highlighted in red

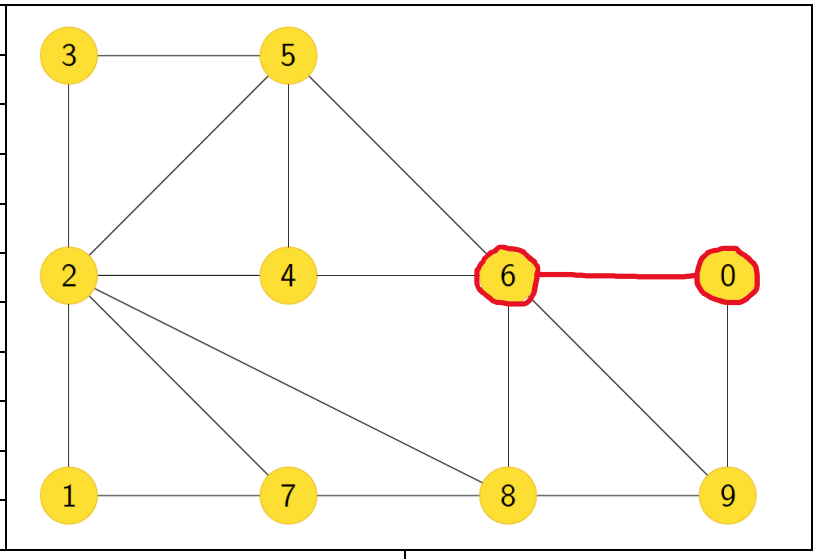
Q4 (4)

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



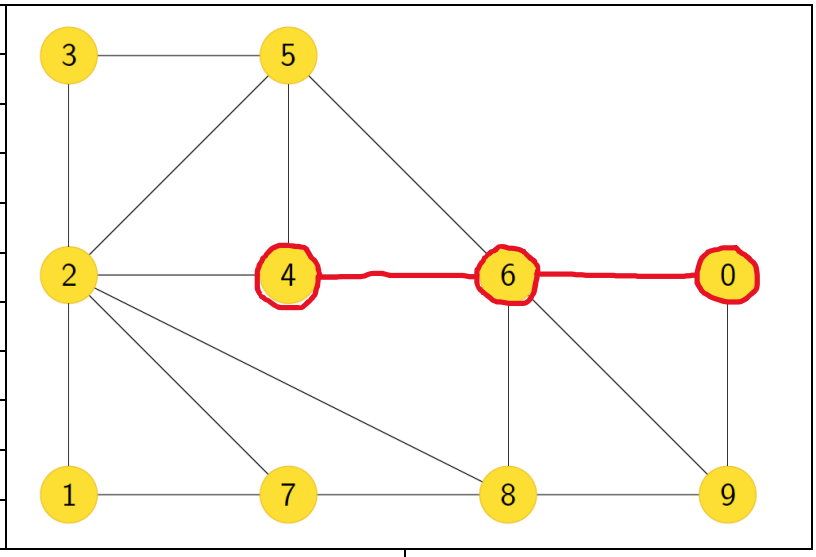
DFS Traversal = 0

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



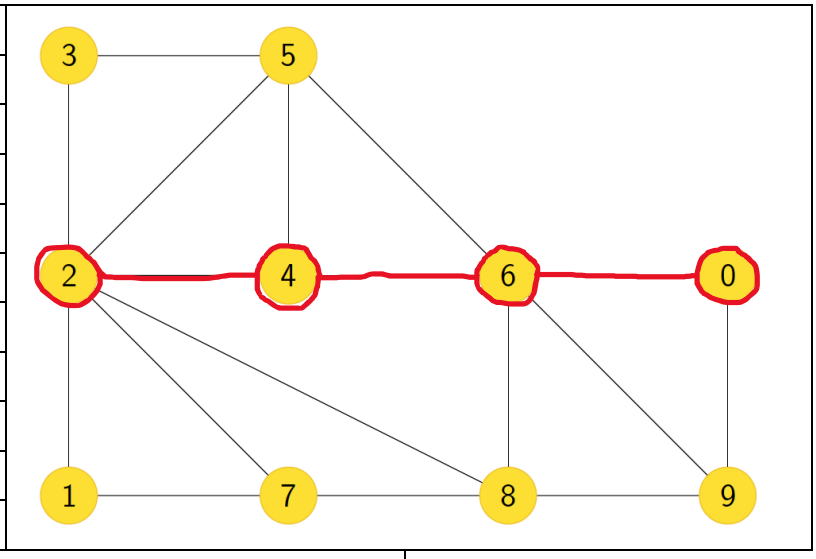
DFS Traversal = 0, 6

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



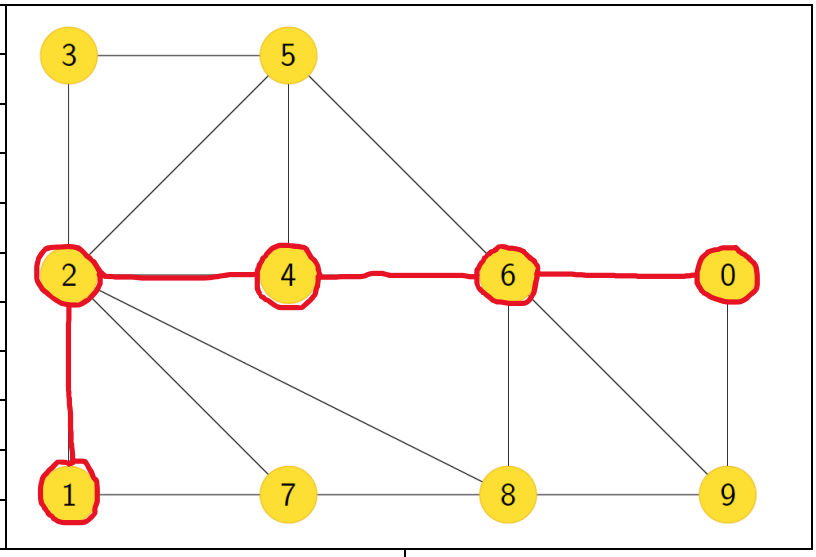
DFS Traversal = 0, 6, 4

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



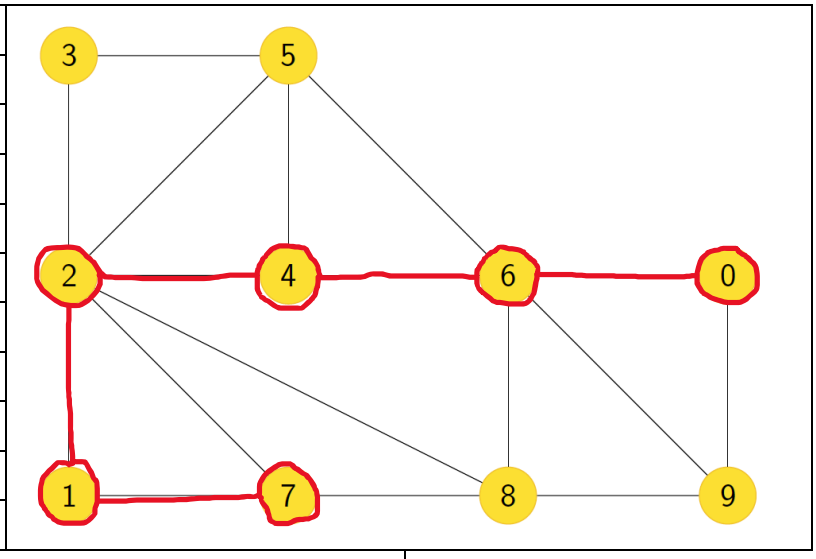
DFS Traversal = 0, 6, 4, 2

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



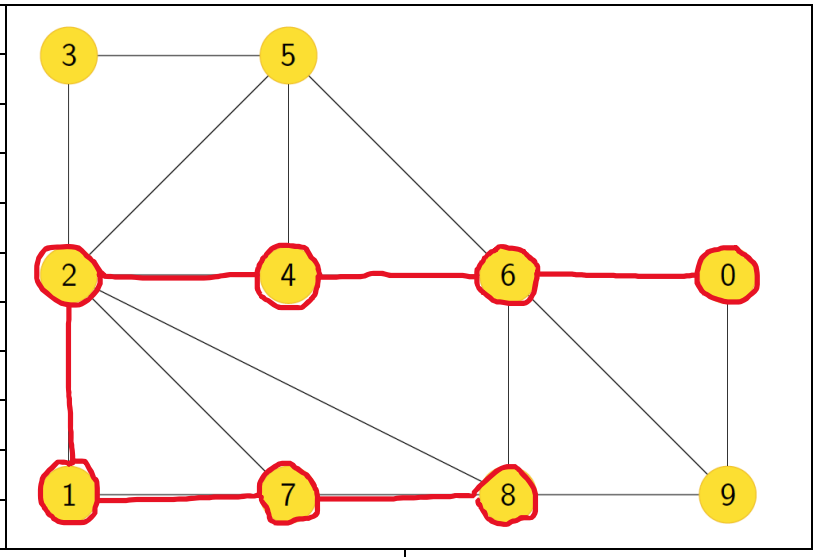
DFS Traversal = 0, 6, 4, 2, 1

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



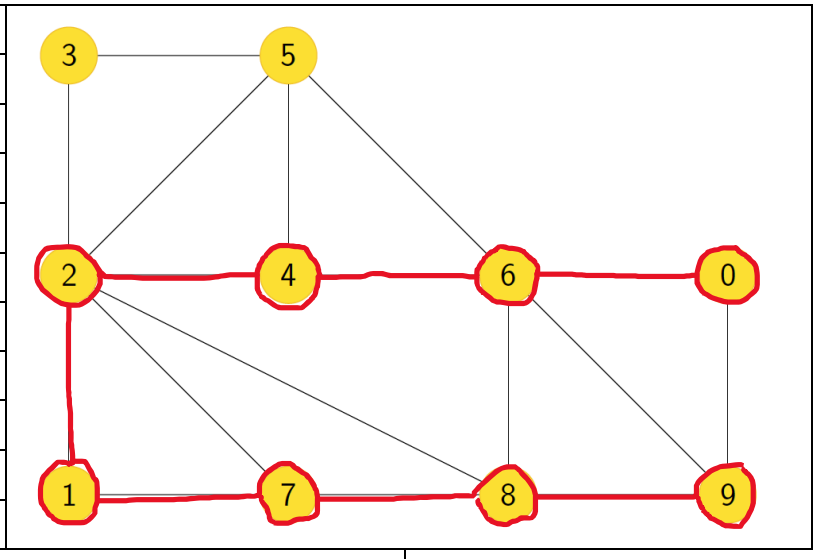
DFS Traversal = 0, 6, 4, 2, 1, 7

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



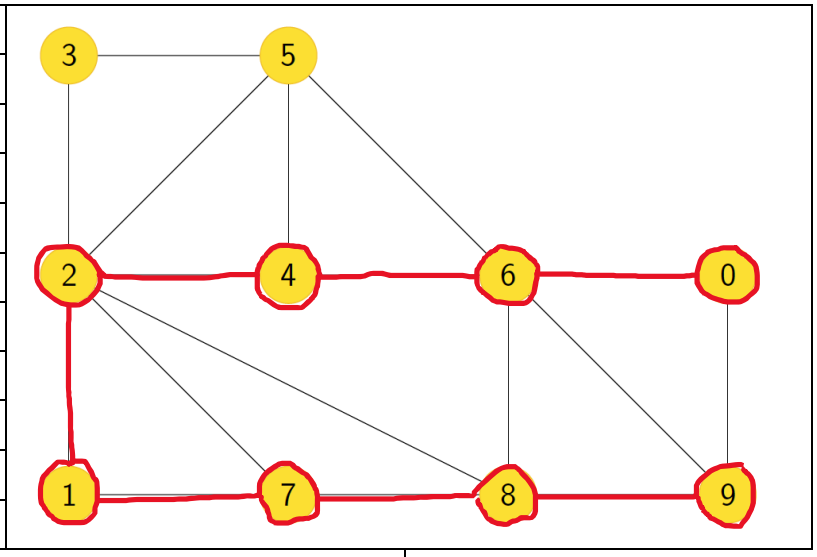
DFS Traversal = 0, 6, 4, 2, 1, 7, 8

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



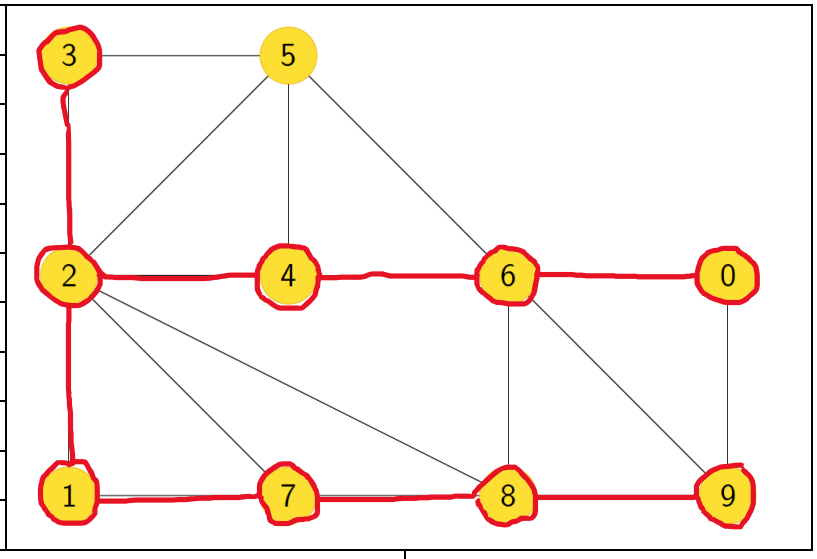
DFS Traversal = 0, 6, 4, 2, 1, 7, 8, 9

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



DFS Traversal = 0, 6, 4, 2, 1, 7, 8, 9

Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



DFS Traversal = 0, 6, 4, 2, 1, 7, 8, 9, 3

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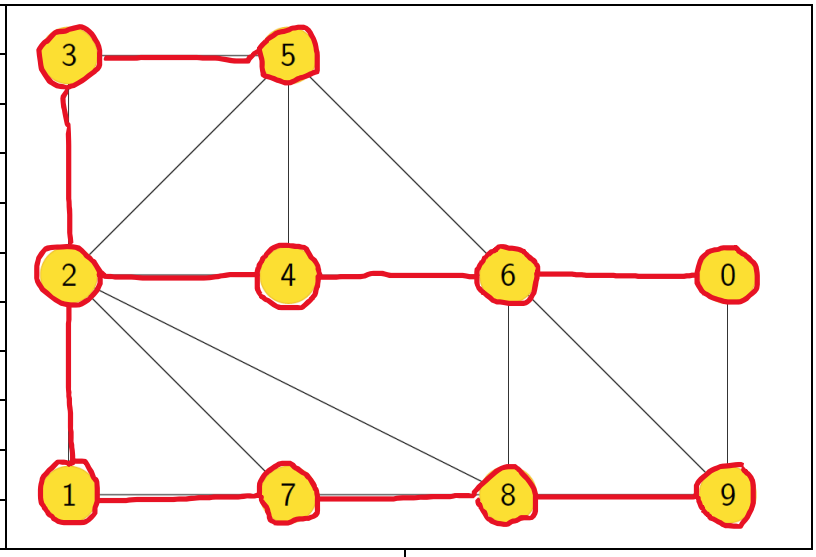
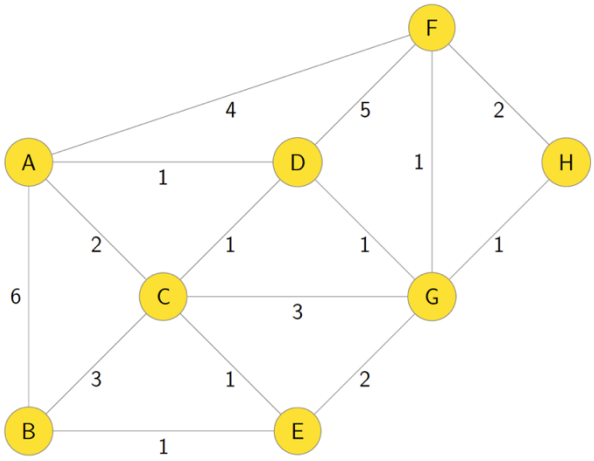
Vertex	Adjacent Vertices					
0	6	9				
1	2	7				
2	1	3	4	5	7	8
3	2	5				
4	2	5	6			
5	2	3	4	6		
6	0	4	5	8	9	
7	1	2	8			
8	2	6	7	9		
9	0	6	8			



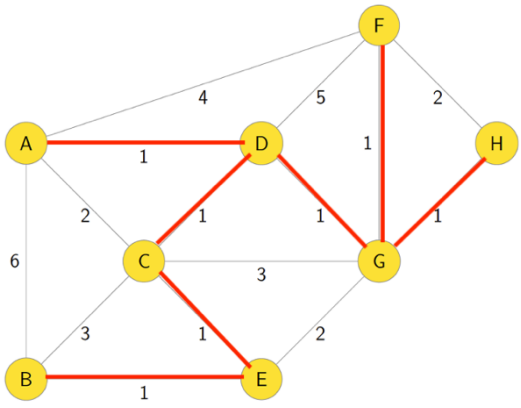
DFS Traversal = 0, 6, 4, 2, 1, 7, 8, 9, 3, 5

DFS Traversal = 0, 6, 4, 2, 1, 7, 8, 9, 3, 5
Note: The tree structure is shown highlighted in red

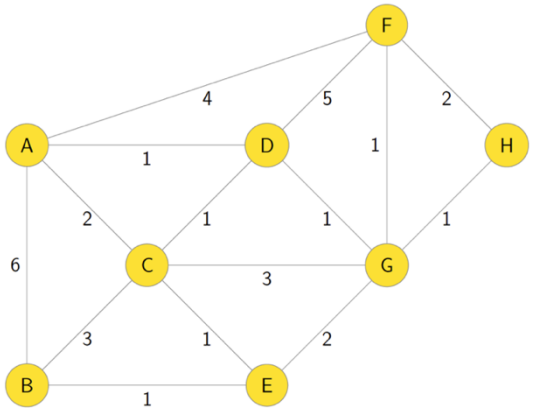
Q5) 1)



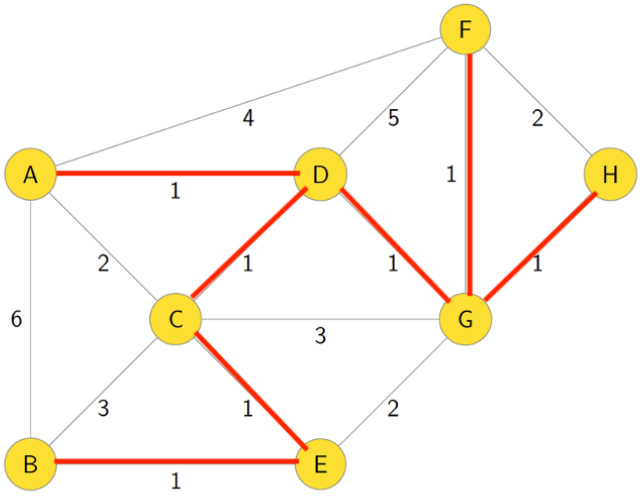
Step	Edge Considered	Cost	Accepted/Rejected
1	AD	1	Accepted
2	CD	1	Accepted
3	CE	1	Accepted
4	BE	1	Accepted
5	GD	1	Accepted
6	FG	1	Accepted
7	GH	1	Accepted
8	AC	2	Rejected
9	EG	2	Rejected
10	FH	2	Rejected
11	BC	3	Rejected
12	CG	3	Rejected
13	AF	4	Rejected
14	DF	5	Rejected
15	AB	6	Rejected



Q5) 2)

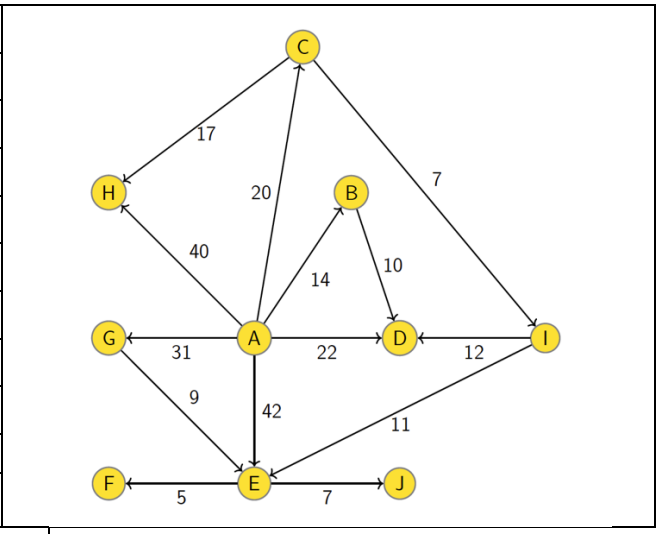


Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
D	Yes	1	A
C	Yes	1	D
E	Yes	1	C
B	Yes	1	E
F	Yes	1	G
G	Yes	1	D
H	Yes	1	G



Q6) (a) BFS topological

In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
1	B	D					
1	C	H	I				
3	D						
3	E	F	J				
1	F						
1	G	E					
2	H						
1	I	D	E				
1	J						



Queue = |A|

BFS Topological =

In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
2	D						
2	E	F	J				
1	F						
0	G	E					
1	H						
1	I	D	E				
1	J						

Queue = |B, C, G|

BFS Topological = A

In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
1	D						
2	E	F	J				
1	F						
0	G	E					
1	H						
1	I	D	E				
1	J						

Queue = |C, G|

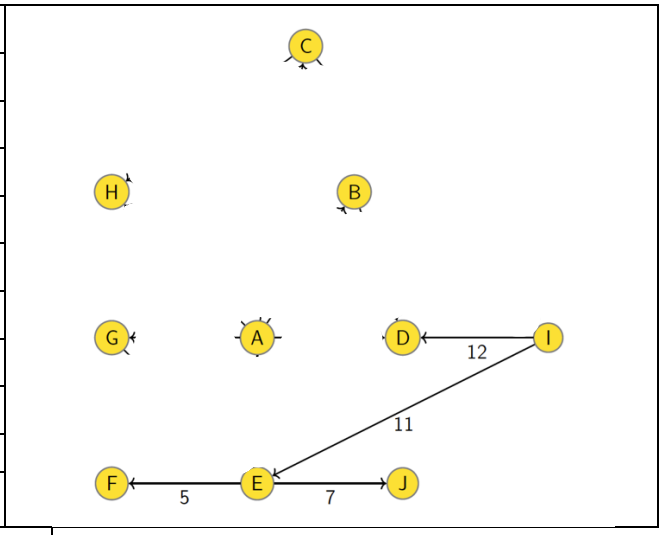
BFS Topological = A, B

In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
1	D						
2	E	F	J				
1	F						
0	G	E					
0	H						
0	I	D	E				
1	J						

Queue = |G, H, I|

BFS Topological = A, B, C

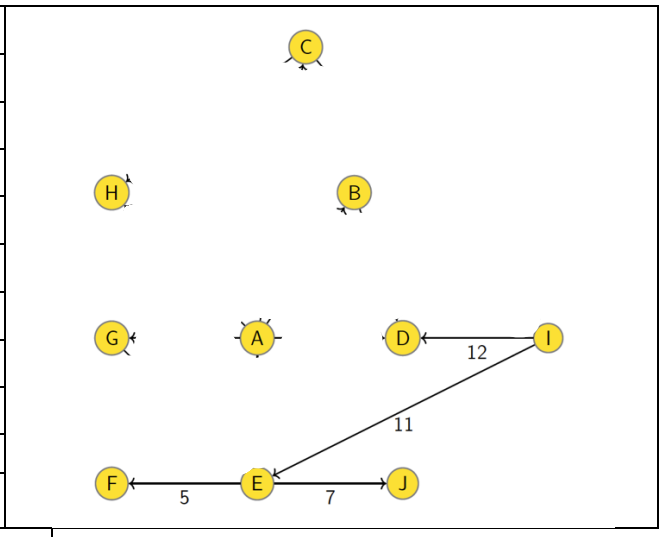
In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
1	D						
1	E	F	J				
1	F						
0	G	E					
0	H						
0	I	D	E				
1	J						



Queue = |H, I|

BFS Topological = A, B, C, G

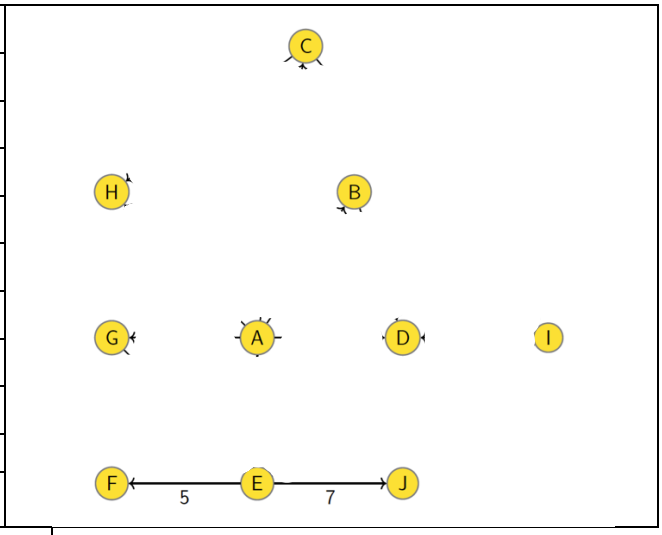
In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
1	D						
1	E	F	J				
1	F						
0	G	E					
0	H						
0	I	D	E				
1	J						



Queue = |I|

BFS Topological = A, B, C, G, H

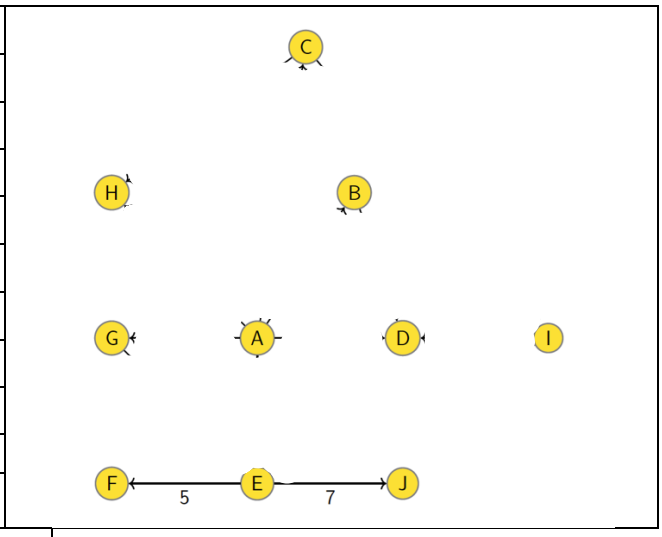
In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
0	D						
0	E	F	J				
1	F						
0	G	E					
0	H						
0	I	D	E				
1	J						



Queue = |D, E|

BFS Topological = A, B, C, G, H, I

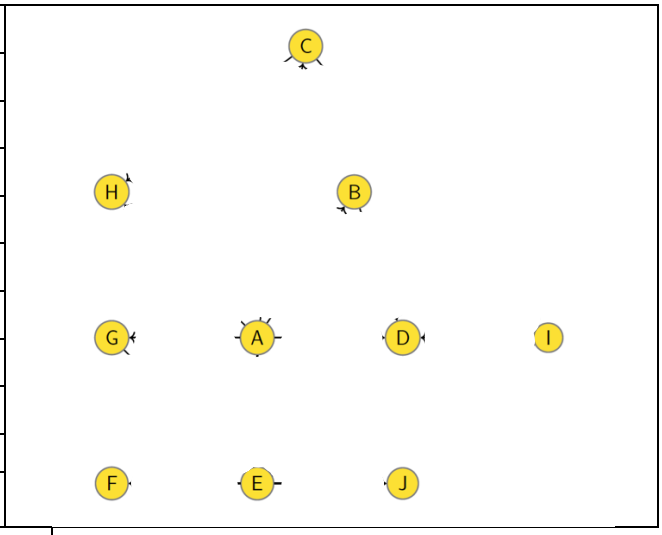
In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
0	D						
0	E	F	J				
1	F						
0	G	E					
0	H						
0	I	D	E				
1	J						



Queue = |E|

BFS Topological = A, B, C, G, H, I, D

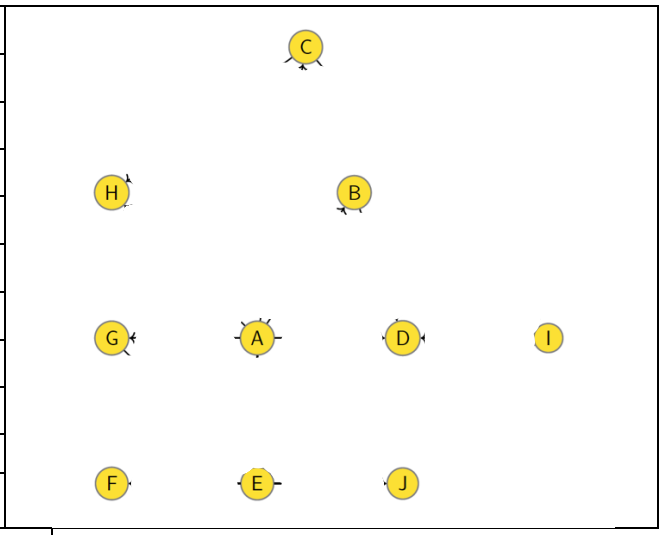
In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
0	D						
0	E	F	J				
0	F						
0	G	E					
0	H						
0	I	D	E				
0	J						



Queue = |F, J|

BFS Topological = A, B, C, G, H, I, D, E

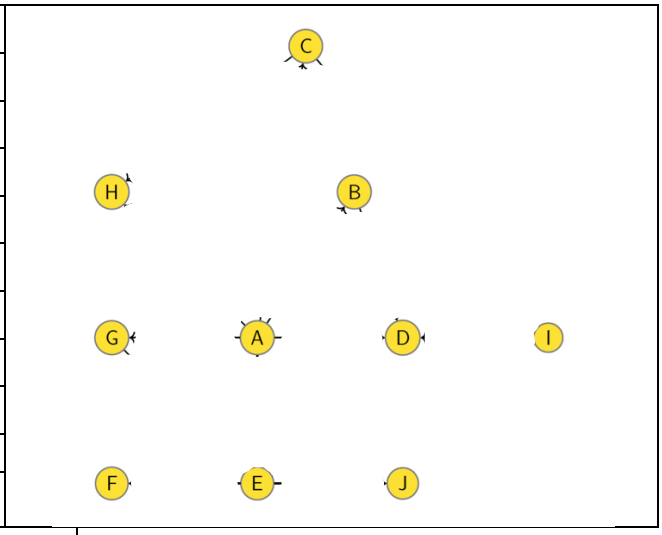
In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
0	D						
0	E	F	J				
0	F						
0	G	E					
0	H						
0	I	D	E				
0	J						



Queue = |J|

BFS Topological = A, B, C, G, H, I, D, E, F

In-Degree	V	Adjacent Vertices					
0	A	B	C	D	E	G	H
0	B	D					
0	C	H	I				
0	D						
0	E	F	J				
0	F						
0	G	E					
0	H						
0	I	D	E				
0	J						



Queue = ||
BFS Topological = A, B, C, G, H, I, D, E, F, J

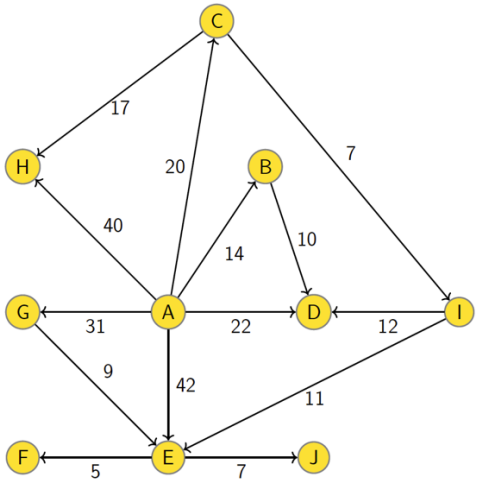
BFS Topological = A, B, C, G, H, I, D, E, F, J

Q6) (a) DFS topological

Algorithm topological Sort DFS(Graph G)
    Initialize a list L
    Mark all vertices as unvisited
    while there exists an unvisited vertex v
        visit(L, v)
    end-while

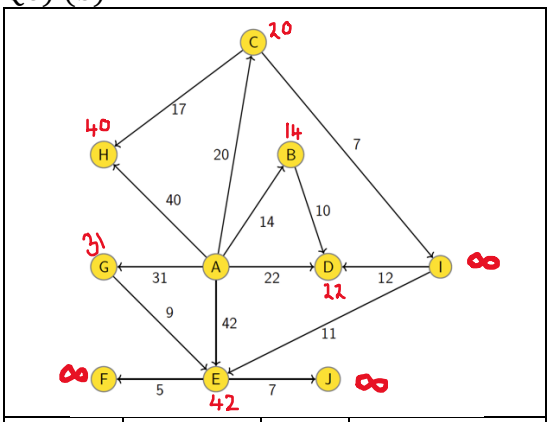
Algorithm visit(L, v)
    if v is unvisited
        for each unvisited neighbor w of v
            visit(L, w)
        end-for
        mark v visited
        add v to front of L
    end-if

- visit(L, A)
  - visit(L, B)
    - visit(L, D)
    - mark D as visited
    - L = {D}
  - mark B as visited
  - L = {B, D}
  - visit(L, C)
    - visit(L, H)
    - mark H as visited
    - L = {H, B, D}
    - visit(L, I)
      - visit(L, E)
        - visit(L, F)
        - mark F as visited
        - L = {F, H, B, D}
        - visit(L, J)
        - mark J as visited
        - L = {J, F, H, B, D}
      - mark E as visited
      - L = {E, J, F, H, B, D}
    - mark I as visited
    - L = {I, E, J, F, H, B, D}
  - mark C as visited
  - L = {C, I, E, J, F, H, B, D}
  - visit(L, G)
  - mark G as visited
  - L = {G, C, I, E, J, F, H, B, D}
- mark A as visited
- L = {A, G, C, I, E, J, F, H, B, D}



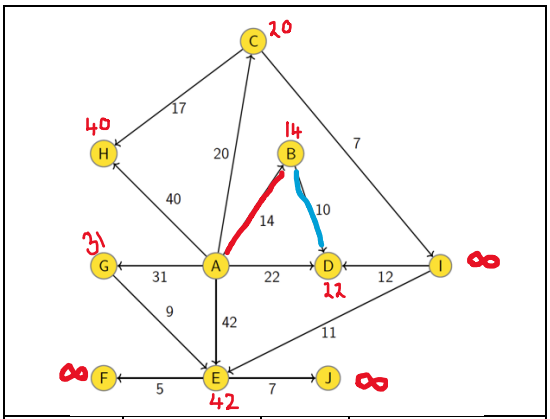
DFS Topological = {A, G, C, I, E, J, F, H, B, D}

Q6) (b)



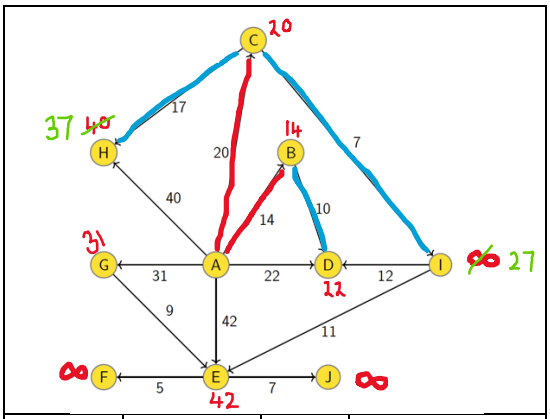
Vertex	Visited?	Cost	Predecessor
A	Yes	0	-

Options	Cost
A,B	14
A,C	20
A,D	22
A,G	31
A,E	42



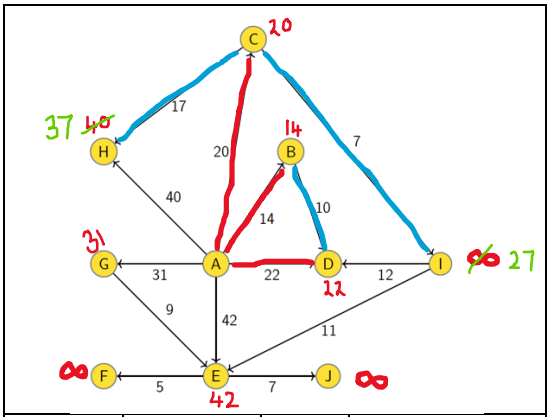
Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A

Options	Cost
A,C	20
A,D	22
A,G	31
A,E	42



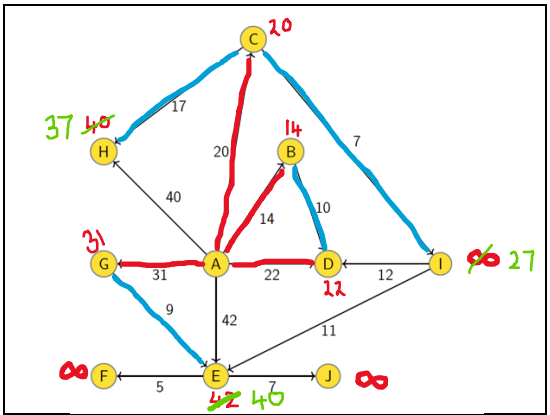
Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A

Options	Cost
A,D	22
A,G	31
A,E	42
C,I	27
C,H	37



Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A

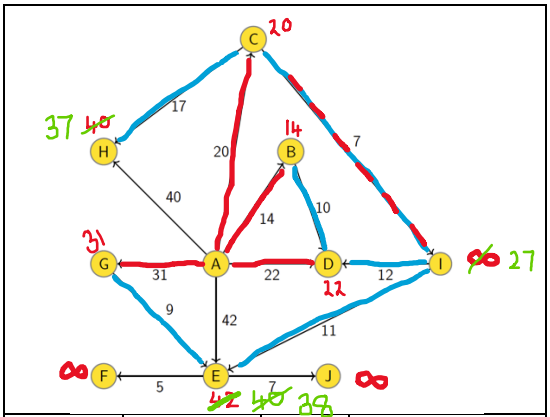
Options	Cost
A,G	31
A,E	42
C,I	27
C,H	37



Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A
G	Yes	31	A

Options	Cost
~~A,E~~	~~42~~
C,I	27
C,H	37
G,E	40

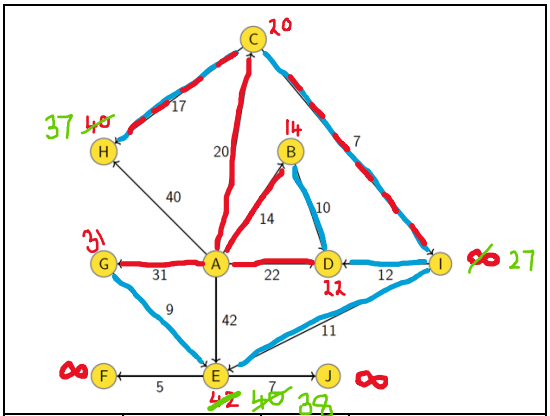
Note: (A,E) is no longer an option because E is relaxed by the edge (G, E).



Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A
G	Yes	31	A
I	Yes	27	C

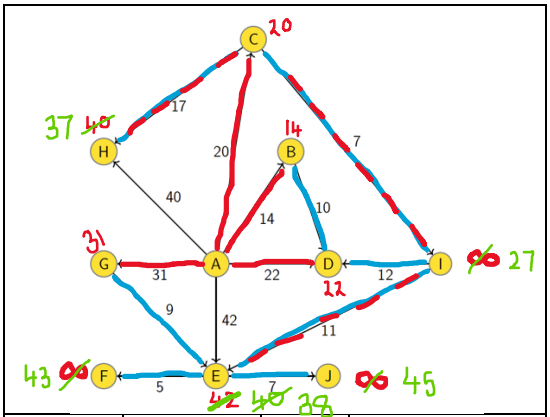
Options	Cost
~~A,E~~	~~42~~
C,H	37
~~G,E~~	~~40~~
I,E	38

Note: (G,E) is no longer an option because E is relaxed by the edge (I, E).



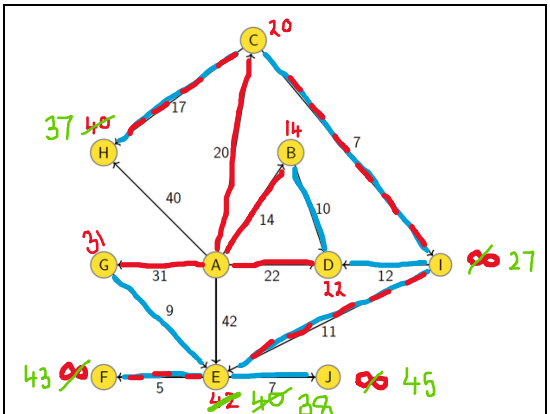
Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A
G	Yes	31	A
I	Yes	27	C
H	Yes	37	C

Options	Cost
~~A,E~~	~~42~~
~~G,E~~	~~40~~
I,E	38



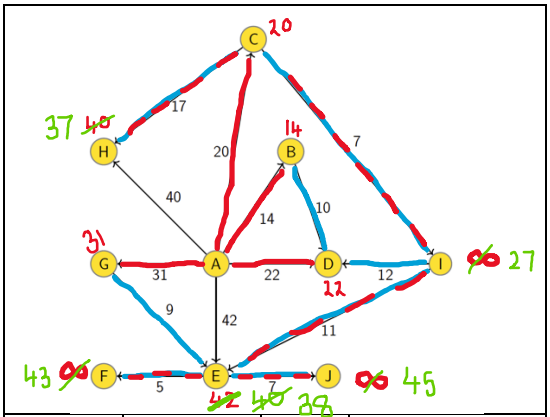
Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A
G	Yes	31	A
I	Yes	27	C
H	Yes	37	C
E	Yes	38	I

Options	Cost
~~A,E~~	~~42~~
~~G,E~~	~~40~~
E,F	43
E,J	45



Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A
G	Yes	31	A
I	Yes	27	C
H	Yes	37	C
E	Yes	38	I
F	Yes	43	E

Options	Cost
~~A,E~~	~~42~~
~~G,E~~	~~40~~
E,J	45



Vertex	Visited?	Cost	Predecessor
A	Yes	0	-
B	Yes	14	A
C	Yes	20	A
D	Yes	22	A
G	Yes	31	A
I	Yes	27	C
H	Yes	37	C
E	Yes	38	I
F	Yes	43	E
J	Yes	45	E

Options	Cost
~~A,E~~	~~42~~
~~G,E~~	~~40~~

Therefore, the shortest distance from node A to every other node is as follows: