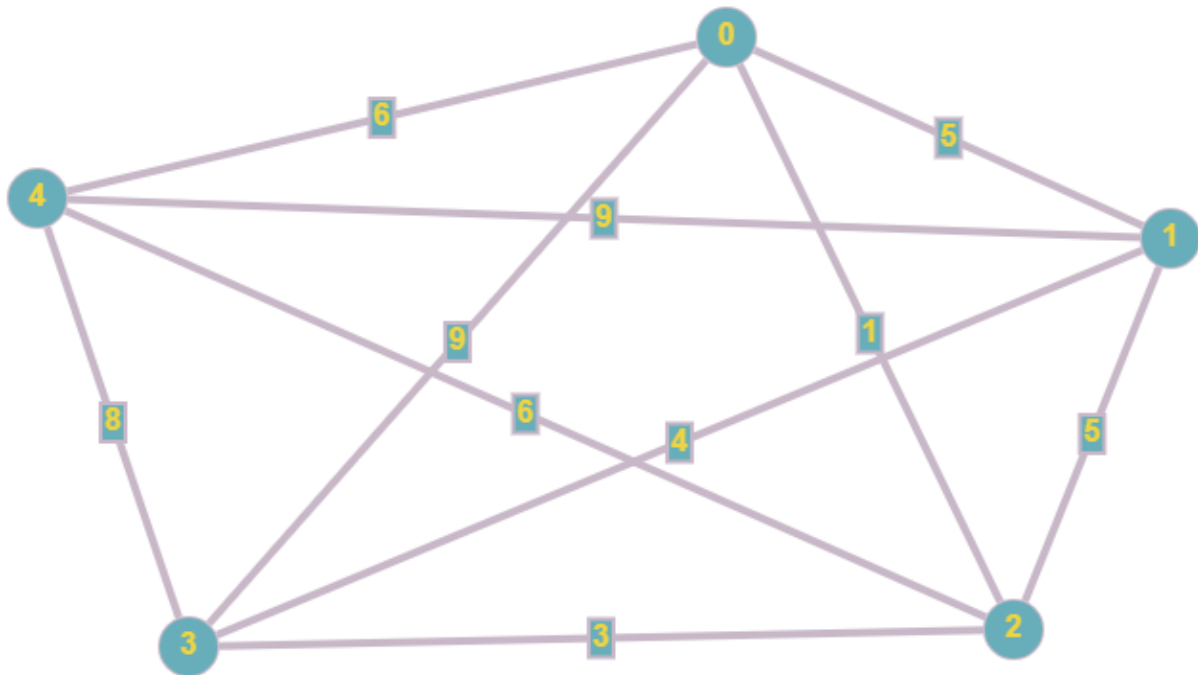


## MANUAL EXECUTION

Input file and representation:



5 10  
0 15  
0 25  
0 39  
0 46  
1 25  
1 34  
1 49  
2 33  
2 46  
3 48

MANUAL EXECUTION - for a graph with 5 vertices

treeEdges = []  
treeCost = 0

treeVertices = {0}

g = []

s = 0  $\Rightarrow$  g = [(5,0,1), (5,0,2), (9,0,3), (6,0,4)]

len(g) > 0?

x cost y

treeVertices

treeEdges

treeCost

z

g (after popping x, y)

g (after pushing y, z)

YES

x = 0  
y = 1  
cost = 5

{0, 1}

[(0, 1)]

5

0

2

3

4

[(5,0,2), (9,0,3), (6,0,4)]

[(5,0,2), (9,0,3), (6,0,4), (5,1,2)]

[(5,0,2), (9,0,3), (6,0,4), (5,1,2),  
(4,1,3)]

[(5,0,2), (9,0,3), (6,0,4), (5,1,2),  
(4,1,3), (9,1,4)]

YES

x = 1  
y = 3  
cost = 4

{0, 1, 3}

[(0, 1), (1, 3)]

9

0

1

2

4

[(5,0,2), (9,0,3), (6,0,4),  
(5,1,2), (9,1,4)]

[(5,0,2), (9,0,3), (6,0,4), (5,1,2),  
(9,1,4), (3,3,2)]

[(5,0,2), (9,0,3), (6,0,4), (5,1,2),  
(9,1,4), (3,3,2), (8,3,4)]

YES

x = 3  
y = 2  
cost = 3

{0, 1, 2, 3}

[(0, 1), (1, 3), (3, 2)]

12

0

1

3

4

[(5,0,2), (9,0,3), (6,0,4),  
(5,1,2), (9,1,4), (8,3,4)]

[(5,0,2), (9,0,3), (6,0,4), (5,1,2),  
(9,1,4), (8,3,4), (6,2,4)]

YES

x = 0  
y = 4  
cost = 6

{0, 1, 2, 3, 4}

[(0, 1), (1, 3), (3, 2), (0, 4)]

18

[(6,2,4), (8,3,4), (9,1,4),  
(9,0,3)]

[(6,2,4), (8,3,4), (9,1,4), (9,0,3)]

AFTER  
POPPING

OTHER VALUES THAT WERE NOT OK FOR CONTINUING: (5,0,2), (5,1,2)

$\text{len}(g) > 0?$	$x, y, \text{cost}$	treeVertices	treeEdges	treeCost	$z$	$g(\text{after popping } x, y)$	$g(\text{after pushing } y, z)$
YES	$x=2$ $y=4$ $\text{cost}=6$	$\{0, 1, 2, 3, 4\}$	$[(0, 1), (1, 3), (3, 2), (0, 4)]$	18	-	$[(8, 3, 4), (9, 0, 3), (9, 1, 4)]$	$[(8, 3, 4), (9, 0, 3), (9, 1, 4)]$
YES	$x=3$ $y=4$ $\text{cost}=8$	$\{0, 1, 2, 3, 4\}$	$[(0, 1), (1, 3), (3, 2), (0, 4)]$	18	-	$[(9, 0, 3), (9, 1, 4)]$	$[(9, 0, 3), (9, 1, 4)]$
YES	$x=0$ $y=3$ $\text{cost}=9$	$\{0, 1, 2, 3, 4\}$	$[(0, 1), (1, 3), (3, 2), (0, 4)]$	18	-	$[(9, 1, 4)]$	$[(9, 1, 4)]$
YES	$x=1$ $y=4$ $\text{cost}=9$	$\{0, 1, 2, 3, 4\}$	$[(0, 1), (1, 3), (3, 2), (0, 4)]$	18	-	[ ]	[ ]
NO							

We end up with the edges  $[(0, 1), (1, 3), (3, 2), (0, 4)]$  and the cost 18. Using the edges, we create an undirected graph for performing a DFS and getting the preorder traversal (consider the costs of the edges).

tree:	call	visited	traversal	neighbours
0: [1, 4]		{ 9 }	[ ]	
1: [0, 3]	DFSUtil(tree, 0, [ ], [ ])	{ 0, 4 }	[ 0 ]	1
2: [3]				3
3: [1, 2]	DFSUtil(tree, 1, { 0, 4 }, [ 0 ])	{ 0, 1, 4 }	[ 0, 1 ]	
4: [0]				2
costs: (0, 1, 0)	DFSUtil(tree, 3, { 0, 1, 4 }, [ 0, 1 ])	{ 0, 1, 3, 4 }	[ 0, 1, 3 ]	
(1, 3, 0)				
(3, 2, 0)	DFSUtil(tree, 2, { 0, 1, 3, 4 }, [ 0, 1, 3 ])	{ 0, 1, 2, 3, 4 }	[ 0, 1, 3, 2 ]	
(0, 4, 0)				
		{ 0, 1, 2, 3, 4 }	[ 0, 1, 3, 2 ]	4
	DFSUtil(tree, 4, { 0, 1, 2, 3, 4 }, [ 0, 1, 3, 2 ])	{ 0, 1, 2, 3, 4 }	[ 0, 1, 3, 2, 4 ]	
		{ 0, 1, 2, 3, 4 }	[ 0, 1, 3, 2, 4 ]	

In the end, we have the traversal  $[0, 1, 3, 2, 4]$  and by completing the cycle we get the following Hamiltonian cycle:

$0 \xrightarrow{5} 1 \xrightarrow{4} 3 \xrightarrow{3} 2 \xrightarrow{6} 4 \xrightarrow{6} 0$   
with a total cost of  $24 < 2 \cdot 18 = 36$ .