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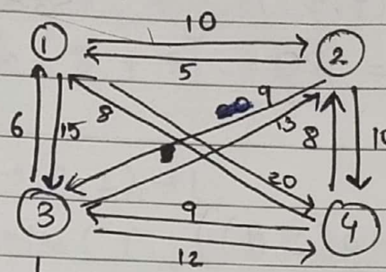
24/7/23
Monday

Travelling Salesman Problem (TSP) :-

1



$\Rightarrow$

	1	2	3	4
1	0	10	15	20
2	5	0	9	10
3	6	13	0	12
4	8	8	9	0

1 Starting Vertex = 1
Ending Vertex = 2

2 Second last vertex can be either 2, 3, 4

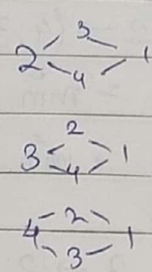
Compute $g(i, \phi) = C_{ij}$ $\quad \therefore j = 1$

$\therefore g(2, \phi) = g(2,1) = C_{21} = 5$

$\therefore g(3, \phi) = g(3,1) = C_{31} = 6$

$\therefore g(4, \phi) = g(4,1) = C_{41} = 8$

3 Therefore, three last vertex can be $\Rightarrow$



1 $2 \rightarrow 3 \rightarrow 1$

$g(2, \{3\}) = \min(C_{23} + g(3, \phi))$
$= \min(9 + 6) = 15$

2 $2 \rightarrow 4 \rightarrow 1$

$g(2, \{4\}) \Rightarrow \min(C_{24} + g(4, \phi))$
$= \min(10 + 8) = 18$

3 $3 \rightarrow 2 \rightarrow 1$

$g(3, \{2\}) = \min(C_{32} + g(2, \phi))$
$= \min(13 + 5) = 18$

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(4) $3 \rightarrow 4 \rightarrow 1$

$\therefore g(3, \{4\}) = \min(C_{34} + g(4, \phi))$

$= \min(12 + 8) = 20$

3 – 4 – 1

4 – 2 – 1, 4 – 3 – 1

(5) $4 \rightarrow 2 \rightarrow 1$

$g(4, \{2\}) = \min(C_{42} + g(2, \phi))$

$= \min(8 + 5) = 13$

(6) $4 \rightarrow 3 \rightarrow 1$

$g(4, \{3\}) = \min(C_{43} + g(3, \phi))$

$= \min(9 + 6) = 15$

(4) Now last 4 vertex can have the following paths :-

(1) $2 \rightarrow (3, 4) \rightarrow 1$

$= \min[C_{23} + g(3, 4, 1)]$

$= \min[9 + 20] = 29$

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

(2) $2 \rightarrow (4, 3) \rightarrow 1$

$= \min[C_{24} + g(4, 3, 1)]$

$= \min[10 + 15] = \boxed{25}$

(3) $3 \rightarrow (2, 4) \rightarrow 1$

$= \min[C_{32} + g(2, 4, 1)]$

$= \min[13 + 18] = 31$

$3 - 2 - 4 \rightarrow 1$, $3 - 4 - 2 \rightarrow 1$

(4) $3 \rightarrow (4, 2) \rightarrow 1$

$\Rightarrow \min[C_{34} + g(4, 2, 1)]$

$\Rightarrow \min[12 + 13] = \boxed{25}$

4 – 2 – 3 – 1
4 – 3 – 2 – 1

⑤ $4 \to (2,3) \to 1$

$\Rightarrow \min [\, C_{42} + g(2,3,1) \,]$

$\Rightarrow \min [\, 8 + 15 \,] = \boxed{23}$

⑥ $4 \to (3,2) \to 1$

$\Rightarrow \min (\, C_{43} + g(\cancel{4,3,2}\; 3,2,1) \,)$

$\Rightarrow \min (9 + 18) = 27$

⑤ This final path can be found as :-

$1 \to \{2,3,4\} \to 1$

$$g(1\{2,3,4\}) = \min [\, C_{12} + g(2\{3,4,1\}),\; C_{13} + g(3\{2,4,1\}),\; C_{14} + g(4\{2,3,1\}) \,]$$

$$= \min [\, 10 + 25,\; 15 + 25,\; 20 + 23 \,] = \min (35, 40, 43)$$

$\therefore$ ~~an~~ $= 35$

$\therefore$ The shortest path is $\boxed{35}$ ~~from~~;

path route $\Rightarrow 1 \xrightarrow{10} 2 \xrightarrow{10} 4 \xrightarrow{9} 3 \xrightarrow{6} 1$

$\therefore 10 + 10 + 9 + 6 \Rightarrow 35$

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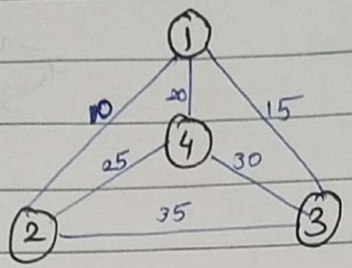
②



	1	2	3	4
1	0	10	15	20
2	10	0	35	25
3	15	35	0	30
4	20	25	30	0

① Starting Vertex = ①
Ending Vertex = ①

② Second last vertex can either be 2, 3, 4

Compute $g(i, \phi) = C_{ij}$ $\boxed{\begin{matrix} \phi = 1 = j \\ i = 2, 3, 4 \end{matrix}}$

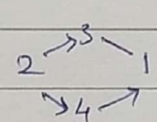
$\therefore g(2, \phi) = g(2, 1) = C_{21} = 10$

$\therefore g(3, \phi) = g(3, 1) = C_{31} = 15$

$\therefore g(4, \phi) = g(4, 1) = C_{41} = 20$

③ Three last vertex can have the following paths :-

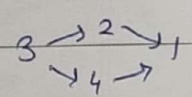
ⓐ $2 \to 3 \to 1$



$g(2, \{3\}) = \min(C_{23} + g(3, \phi))$
$= \min(35 + 15)$
$= 50$

ⓑ $2 \to 4 \to 1$

$g(2, \{4\}) = \min(C_{24} + g(4, \phi))$
$= \min(25 + 20) = 45$



ⓒ $3 \to 2 \to 1$

$\Rightarrow g(3, \{2\}) = \min[C_{32} + g(2, \phi)] = \min[35 + 10] = 45$

ⓓ $3 \to 4 \to 1$

$g(3\{4\}) = \min[C_{34} + g(4, \phi)] = \min[30 + 20] = 50$

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4 → 3 → 1
  → 2 →

ⓔ 4 → 2 → 1

$\Rightarrow g(4\{2\}) = \min[C_{42} + g(2,\phi)] = \min[25 + 10] = 35$

ⓕ 4 → 3 → 1

$\Rightarrow g(4,\{3\}) = \min[C_{43} + g(3,\phi)] = \min[30 + 15] = 45$

④ ∴ The last 4 vertex can have the following paths:-

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

ⓐ 2 → (3,4) → 1

$\Rightarrow \min[C_{23} + g(3,4,1)]$

$\Rightarrow \min[35 + 50] = 85$

ⓑ $2 \to (4,3) \to 1 \Rightarrow \min[C_{24} + g(4,3,1)] = \min[25 + 45] = \boxed{70}$

ⓒ $3 \to (2,4) \to 1 \Rightarrow \min[C_{32} + g(2,4,1)] = \min(35 + 45) = 80$

ⓓ $3 \to (4,2) \to 1 \Rightarrow \min[C_{34} + g(4,2,1)] = \min(30 + 35) = \boxed{65}$

ⓔ $4 \to (2,3) \to 1 \Rightarrow \min[C_{42} + g(2,3,1)] = \min(25 + 50) = 75$

ⓕ $4 \to (3,2) \to 1 = \min[C_{43} + g(3,2,1)] = \min(30 + 45) = \boxed{75}$

⑤ So the final path can be calculated as:-

$$1 \to (2,3,4) \to 1 = \min[C_{12} + g(2\{3,4,1\}),\ C_{13} + g(3\{2,4,1\}),\ C_{14} + g(4\{2,3,1\})]$$

$$= \min[10 + 70,\ 15 + 65,\ 20 + 75] \Rightarrow \min[80, 80, 95]$$

∴ There are minimum 2 routes ie [Paths route]

① ~~1 → 3 → 2 →~~ $1 \xrightarrow{10} 2 \xrightarrow{25} 4 \xrightarrow{30} 3 \xrightarrow{15} 1 = 80$

② $1 \xrightarrow{15} 3 \xrightarrow{30} 4 \xrightarrow{25} 2 \xrightarrow{10} 1 = 80$

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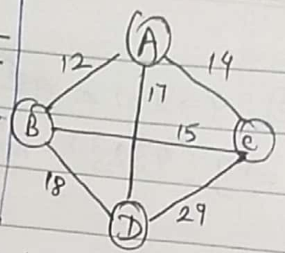
③ ① → Starting Vertex = A
Ending Vertex = A



② Second last vertex can either be B, C, D :-

Compute $g(i, \phi) = C_{ij}$ $\phi = 1$; $i = B, C, D$

$g(B, \phi) = g(B, A) = C_{BA} = 12$

$g(C, \phi) = g(C, A) = C_{CA} = 14$

$g(D, \phi) = g(D, A) = C_{DA} = 17$

	A	B	C	D
A	0	12	14	17
B	12	0	15	18
C	14	15	0	29
D	17	18	29	0

③ Three last vertex can have the following paths :-

B →(C / D)→ A   C →(B / D)→ A   D →(B / C)→ A

ⓐ $B \to C \to A = g[B, \{C\}] = \min[C_{BC} + g(C, \phi)]$
$= \min[15 + 14] = 29$

ⓑ $B \to D \to A = g[B, \{D\}] = \min[C_{BD} + g(D, \phi)]$
$= \min[18 + 17] = 35$

ⓒ $C \to B \to A = g[C, \{B\}] = \min[C_{CB} + g(B, \phi)]$
$= \min[15 + 12] = 27$

ⓓ $C \to D \to A = g[C, \{D\}] = \min[C_{CD} + g(D, \phi)]$
$= \min[29 + 17] = 46$

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(e) $D \rightarrow B \rightarrow A = g(D, \{B\}) = \min[C_{DB} + g(B, \phi)]$
$= \min[18 + 12] = 30$

(f) $D \rightarrow C \rightarrow A = g(D, \{C\}) = \min[C_{DC} + g(C, \phi)]$
$= \min[29 + 14] = 43$

(4) Last 4 vertex can have the following paths :-

(a) $B \rightarrow (C, D) \rightarrow A$

$B \rightarrow C \rightarrow D \rightarrow A$, $B \rightarrow D \rightarrow C \rightarrow A$

$\Rightarrow \min[C_{BC} + g(C, D, A)]$
$= \min[15 + 46] = 61$

(b) $B \rightarrow (D, C) \rightarrow A \Rightarrow \min[C_{BD} + g(D, C, A)]$
$\Rightarrow \min[18 + 43] = \boxed{61}$

$C \rightarrow B \rightarrow D \rightarrow A$, $C \rightarrow D \rightarrow B \rightarrow A$

(c) $C \rightarrow (B, D) \rightarrow A = \min[C_{CB} + g(B, D, A)]$
$= \min[15 + 35] = \boxed{50}$

(d) $C \rightarrow (D, B) \rightarrow A = \min[C_{CD} + g(D, B, A)]$
$= \min[29 + 30] = 59$

$D \rightarrow B \rightarrow C \rightarrow A$, $D \rightarrow C \rightarrow B \rightarrow A$

(e) $D \rightarrow (B, C) \rightarrow A \Rightarrow \min[C_{DB} + g(B, C, A)]$
$\Rightarrow \min[18 + 29] = \boxed{47}$

(f) $D \rightarrow (C, B) \rightarrow A \Rightarrow \min[C_{DC} + g(C, B, A)]$
$= \min[29 + 27] = 56$

(5) The final route can be :-

$A \rightarrow (B, C, D) \rightarrow A = \min[C_{AB} + g(B\{C, D, A\}),$
$C_{AC} + g(C\{B, D, A\}),$
$C_{AD} + g(D\{B, C, A\})]$

$\Rightarrow \min \left[\begin{array}{l} 12 + 61, \\ 14 + 50, \\ 17 + 47 \end{array} \right] \Rightarrow \min[73, 64, 64]$

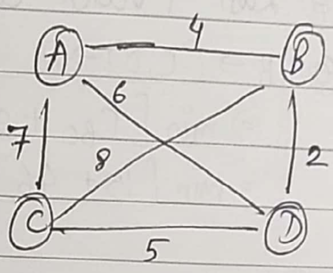
$\therefore$ The shortest route/path is 64

from route :-

$\underset{14}{A \rightarrow} \underset{15}{C \rightarrow} \underset{18}{B \rightarrow} \underset{17}{D \rightarrow} A \Rightarrow 64$ AND $\underset{17}{A \rightarrow} \underset{18}{D \rightarrow} \underset{15}{B \rightarrow} \underset{14}{C \rightarrow} A = 64$

Q4)

	A	B	C	D
A	0	4	7	6
B	4	0	8	2
C	7	8	0	5
D	6	2	5	0



① Starting Vertex = A

Ending Vertex = A

② Second last vertex can either be B, C, D;

Compute $g(i, \phi) = C_{ij}$ $i = B, C, D$; $\phi = A$;

$\therefore g(B, \phi) = g(B, A) = C_{BA} = 4$

$\therefore g(C, \phi) = g(C, A) = C_{CA} = 7$

$\therefore g(D, \phi) = g(D, A) = C_{DA} = 6$

③ Last 3 vertex can have the following path :-

ⓐ $B \rightarrow C \rightarrow A$; $g(B, \{C\}) = [C_{BC} + g(C, \phi)]$ $B \overset{C}{\rightarrow} A$, $B \underset{D}{\rightarrow} A$

$= [8 + 7] = 15$

ⓑ $B \rightarrow D \rightarrow A \Rightarrow g(B, \{D\}) \Rightarrow \min[C_{BD} + g(D, \phi)]$

$= \min[2 + 6] = 8$

(c) $C \to D \to A \Rightarrow g(C, \{D\}) \Rightarrow \min[C_{CD} + g(D, \phi)]$
$\Rightarrow \min[5+6] \Rightarrow 11$

$C \to B \to A$, $\to D \to$

$D \to B \to A$, $\to C$

(d) $C \to B \to A \Rightarrow g(C, \{B\}) = \min[C_{CB} + g(B, \phi)]$
$= \min[8+4] = 12$.

(e) $D \to B \to A \Rightarrow g(D, \{B\}) \Rightarrow \min[C_{DB} + g(B, \phi)]$
$\Rightarrow \min[2+4] = 6$

(f) $D \to C \to A \Rightarrow g(D, \{C\}) = \min[C_{DC} + g(C, \phi)]$
$= \min[5+7] = 12$

(4) Last 4 vertex can have the following path :-

(a) $B \to (C, D) \to A \Rightarrow \min[C_{BC} + g(C, D, A)] = \min[8+11] = 19$

(b) $B \to (D, C) \to A \Rightarrow \min[C_{BD} + g(D, C, A)] = \min[2+12] = \boxed{14}$

(c) $C \to (B, D) \to A \Rightarrow \min[C_{CB} + g(B, D, A)] = \min[8+8] = 16$

(d) $C \to (D, B) \to A \Rightarrow \min[C_{CD} + g(D, B, A)] = \min[5+6] = \boxed{11}$

(e) $D \to (B, C) \to A \Rightarrow \min[C_{DB} + g(B, C, A)] = \min[2+15] = 17$

(f) $D \to (C, B) \to A \Rightarrow \min[C_{DC} + g(C, B, A)] = \min[5+12] = \boxed{17}$

(5) So the final route can be :-

$A \to (B, C, D) \to A \Rightarrow \min[C_{AB} + g(B\{C, D, A\}),$
$C_{AC} + g(C\{B, D, A\}),$
$C_{AD} + g(D\{C, B, A\})]$

$\Rightarrow \min[4+14, 7+11, 6+17] \Rightarrow \min[18, 18, 23] \Rightarrow 18$

$\therefore$ The final shortest route is :-

$A \to B \to D \to C \to A = 18$ & $A \to C \to D \to B \to A = 18$

$\boxed{4+2+5+7 = 18}$ $\boxed{7+5+2+4 = 18}$

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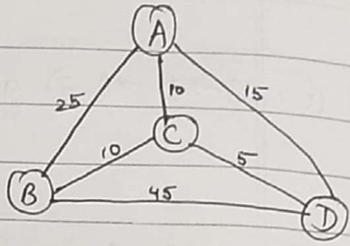
(5)

	A	B	C	D
A	0	25	10	15
B	25	0	10	45
C	10	10	0	5
D	15	45	5	0



① Starting Vertex ⇒ A
Ending Vertex ⇒ A

② Second last vertex can either ~~Be~~ be B, C, D:-

Compute $g(i, \phi) = C_{ij}$; $i = B, C, D$

$g(B, \phi) = g(B, A) = C_{BA} = 25$ $\phi = 1$

$g(C, \phi) = g(C, A) = C_{CA} = 10$

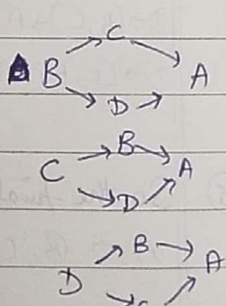
$g(D, \phi) = g(D, A) = C_{DA} = 15$

③ Last 3 vertex can have the following path:-

(a) $B \to C \to A$

$g(B\{C\}) = [C_{BC} + g(C, \phi)]$

$= [10 + 10] = 20$



(b) $B \to D \to A$

* $g(B\{D\}) = [C_{BD} + g(D, \phi)]$

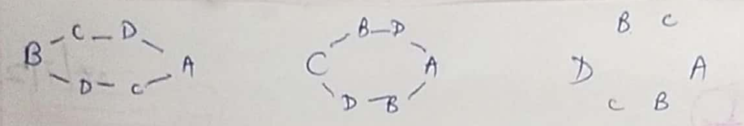
$= [45 + 15] = 60$

(c) $C \to B \to A \Rightarrow g(C\{B\}) = [C_{CB} + g(B, \phi)] = [10 + 25] = 35$

(d) $C \to D \to A \Rightarrow g(C\{D\}) = [C_{CD} + g(D, \phi)] = [5 + 15] = 20$

(e) $D \to B \to A \Rightarrow g(D\{B\}) = [C_{DB} + g(B, \phi)] = [45 + 25] = 70$

(f) $D \to C \to A \Rightarrow g(D\{C\}) = [C_{DC} + g(C, \phi)] = [5 + 10] = 15$



(4) Last 4 vertex can have the following paths :-

(a) $B \rightarrow \{C \rightarrow D\} \rightarrow A \Rightarrow \min [C_{BC} + g(C, D, A)] = 10 + 20 = \boxed{30}$

(b) $B \rightarrow (D, C) \rightarrow A \Rightarrow \min [C_{BD} + g(D, C, A)] = 45 + 15 = 60$

(c) $C \rightarrow (B, D) \rightarrow A \Rightarrow \min [C_{CB} + g(B, D, A)] = 10 + 60 = \boxed{70}$

(d) $C \rightarrow (D, B) \rightarrow A \Rightarrow \min [C_{CD} + g(D, B, A)] = 5 + 70 = 75$

(e) $D \rightarrow (B, C) \rightarrow A = \min [C_{DB} + g(B, C, A)] = 45 + 20 = 65$

(f) $D \rightarrow (C, B) \rightarrow A = \min [C_{DC} + g(C, B, A)] = 5 + 35 = \boxed{40}$

(5) The final route can be :-

$A \rightarrow (B, C, D) \rightarrow A =$

$$\Rightarrow \min \begin{bmatrix} C_{AB} + g(B, \{C, D, A\}), \\ C_{AC} + g(C, \{B, D, A\}), \\ C_{AD} + g(D, \{B, C, A\}) \end{bmatrix} \Rightarrow \min \begin{bmatrix} 25 + 30 \\ 10 + 70 \\ 15 + 40 \end{bmatrix}$$

$\Rightarrow \min [55, 80, 55]$

∴ The shortest route is 55 from

$A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$

$25 + 10 + 5 + 15 = 55$

$A \rightarrow D \rightarrow C \rightarrow B \rightarrow A$

$15 \quad 5 \quad 10 \quad 25 \quad = 55$

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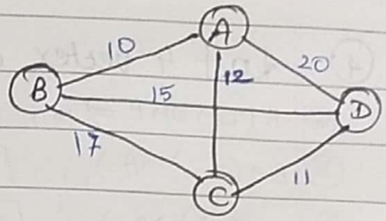
(6)

	A	B	C	D
A	0	10	12	20
B	10	0	17	15
C	12	17	0	11
D	20	15	11	0



(1) Starting Vertex :⇒ A
Ending Vertex ⇒ A

(2) Second last vertex can either be B, C, or D
Compute $g(i, \phi) = C_{ij}$; $i = B, C, D$
$\phi = A = j$
$g(B, \phi) = g(B, A) = C_{BA} = 10$
$g(C, \phi) = g(C, A) = C_{CA} = 12$
$g(D, \phi) = g(D, A) = C_{DA} = 20$

(3) Third last vertex can have the following path :-
(a) $B \to C \to A \Rightarrow g(B, \{C\}) \Rightarrow [C_{BC} + g(C; \phi)] = [17 + 12] = 29$
(b) $B \to D \to A \Rightarrow g(B, \{D\}) \Rightarrow [C_{BD} + g(D, \phi)] = [15 + 20] = 35$
(c) $C \to B \to A \Rightarrow g[C, \{B\}] \Rightarrow [C_{CB} + g(B, \phi)] = [17 + 10] = 27$
(d) $C \to D \to A \Rightarrow g[C, \{D\}] = [C_{CD} + g(D, \phi)] = 11 + 20 = 31$
(e) $D \to B \to A \Rightarrow g[D, \{B\}] = [C_{DB} + g(B, \phi)] = [15 + 10] = 25$
(f) $D \to C \to A \Rightarrow g[D, \{C\}] = [C_{DC} + g(C, \phi)] = [11 + 12] = 23$

(4) Fourth last vertex can have the following paths :-
(a) $B \to (C, D) \to A \Rightarrow [C_{BC} + g(C, D, A)] = [17 + 31] = 48$
(b) $B \to (D, C) \to A \Rightarrow [C_{BD} + g(D, C, A)] = [15 + 23] = 38$
(c) $C \to (B, D, A) \Rightarrow [C_{CB} + g(B, D, A)] = 17 + 35 = 52$
(d) $C \to (D, B) \to A \Rightarrow [C_{CD} + g(D, B, A)] = 11 + 25 = 36$
(e) $D \to (B, C) \to A \Rightarrow [C_{DB} + g(B, C, A)] = 15 + 29 = 44$
(f) $D \to (C, B) \to A \Rightarrow [C_{DC} + g(C, B, A)] = 11 + 27 = 38$

⑤ Now the final path can be calculated as:-

$A \to (B, C, D) \to A \Rightarrow \min[C_{AB} + g(B\{C, D, A\}),$
$C_{AC} + g(C\{B, D, A\}),$
$C_{AD} + g(D\{B, C, A\})]$

$\Rightarrow \min[10 + 38, \; 12 + 36, \; 20 + 38] \Rightarrow \min[48, 48, 58] \Rightarrow 48$

The shortest path is 48 ie;

∴ The shortest path can be :-

$A \xrightarrow{10} B \xrightarrow{17} C \xrightarrow{11} D \xrightarrow{20} A$ AND $A \xrightarrow{12} C \xrightarrow{17} B \xrightarrow{15} D \xrightarrow{20} A$

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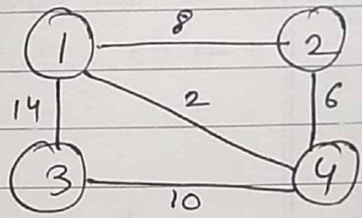
	~~A~~	~~B~~	~~C~~	~~D~~
~~1~~				
~~2~~				
~~3~~				
~~4~~				



	1	2	3	4
1	0	8	14	2
2	8	0	0	6
3	14	0	0	10
4	2	6	10	0

① Starting & Ending vertex = 1

② Second last vertex can ~~have the~~ either ~~following paths~~ be 2, 3, 4 :-

Compute $g(i, \phi) = C_{i1} \Rightarrow i = 2, 3, 4;\ j = 1 = \phi$

$\therefore g(2, \phi) = g(2, 1) = C_{21} = 8$

$\therefore g(3, \phi) = g(3, 1) = C_{31} = 14$

$\therefore g(4, \phi) = g(4, 1) = C_{41} = 2$

③ Third last vertex can have the following paths :-

$2 \to 3 \to 1$, $2 \to 4 \to 1$

ⓐ $2 \to 3 \to 1 \Rightarrow g(2, \{3\}) = [C_{23} + g(3, \phi)] = [0 + 14] = 14$

ⓑ $2 \to 4 \to 1 \Rightarrow g(2, \{4\}) = [C_{24} + g(4, \phi)] = [6 + 2] = 8$

ⓒ $3 \to 2 \to 1 \Rightarrow g(3, \{2\}) = [C_{32} + g(2, \phi)] = [0 + 8] = 8$

ⓓ $3 \to 4 \to 1 \Rightarrow g(3, \{4\}) = [C_{34} + g(4, \phi)] = [10 + 2] = 12$

ⓔ $4 \to 2 \to 1 \Rightarrow g(4, \{2\}) = [C_{42} + g(2, \phi)] = [6 + 8] = 14$

ⓕ $4 \to 3 \to 1 \Rightarrow g(4, \{3\}) = [C_{43} + g(3, \phi)] = [10 + 14] = 24$

(4) Fourth vertex can have the following path :-

(a) $2 \to (3,4) \to 1 \Rightarrow [C_{23} + g(\{3,4,1\})] \Rightarrow [0 + 12] = \boxed{12}$

(b) $2 \to (4,3) \to 1 \Rightarrow [C_{24} + g(\{4,3,1\})] \Rightarrow [6 + 24] = 30$

(c) $3 \to (2,4) \to 1 \Rightarrow [C_{32} + g(2,4,1)] \Rightarrow \boxed{8}$

(d) $3 \to (4,2) \to 1 \Rightarrow [C_{34} + g(4,2,1)] \Rightarrow 10 + 14 = 24$

(e) $4 \to (2,3) \to 1 \Rightarrow [C_{42} + g(2,3,1)] \Rightarrow 6 + 14 = 20$

(f) $4 \to (3,2) \to 1 \Rightarrow [C_{43} + g(3,2,1)] \Rightarrow 10 + 8 \Rightarrow \boxed{18}$

(5) ∴ The final route can be :-

$$1 \to (2,3,4) \to 1 \Rightarrow \min[C_{12} + g(2\{3,4,1\}),\ C_{13} + g(3\{2,4,1\}),\ C_{14} + g(4\{2,3,1\})]$$

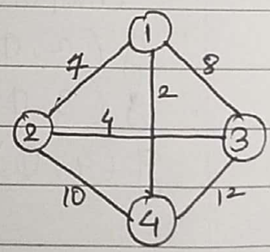
$$\Rightarrow \min[8 + 12,\ 14 + 8,\ 2 + 18] \Rightarrow \min[20, 22, 20] \Rightarrow 20$$

∴ The final route is 20; Then the shortest path can be ~~fort~~ formed by :-

$1 \to 2 \to 3 \to 4 \to 1$ AND $1 \to 4 \to 3 \to 2 \to 1$

29/~~8~~July/23

	1	2	3	4
1	0	7	8	2
2	7	0	4	10
3	8	4	0	12
4	2	10	12	0



(1) Starting Vertex ⇒ 1

Ending Vertex ⇒ 1

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(2) Second vertex can either be 2, 3, 4 :-

Compute $g(i, \phi) = C_{ij}$; $i = 2,3,4$; ϕ or $j = 1$

$\therefore g(2, \phi) = g(2,1) = C_{21} = 7$

$\therefore g(3, \phi) = g(3,1) = C_{31} = 8$

$\therefore g(4, \phi) = g(4,1) = C_{41} = 2$

(3) Third ~~vee~~ last vertex can have the following paths :-

(a) $2 \to 3 \to 1 \Rightarrow g(2, \{3\}) \Rightarrow [C_{23} + g(3, \phi)] = 4 + 8 = 12$

(b) $2 \to 4 \to 1 \Rightarrow g(2, \{4\}) \Rightarrow [C_{24} + g(4, \phi)] = 10 + 2 = 12$

(c) $3 \to 2 \to 1 \Rightarrow g(3, \{2\}) \Rightarrow [C_{32} + g(2, \phi)] = 4 + 7 = 11$

(d) $3 \to 4 \to 1 \Rightarrow g(3, \{4\}) \Rightarrow [C_{34} + g(4, \phi)] = 12 + 2 = 14$

(e) $4 \to 2 \to 1 \Rightarrow g(4, \{2\}) \Rightarrow [C_{42} + g(2, \phi)] = 10 + 7 = 17$

(f) $4 \to 3 \to 1 \Rightarrow g(4, \{3\}) \Rightarrow [C_{43} + g(3, \phi)] = 12 + 8 = 20$

(4) fourth last vertex can have the following paths :-

(a) $2 \to (3,4) \to 1 \Rightarrow [C_{23} + g(3,4,1)] \Rightarrow 4 + 14 = \boxed{18}$

(b) $2 \to (4,3) \to 1 \Rightarrow [C_{24} + g(4,3,1)] \Rightarrow 10 + 20 = 30$

(c) $3 \to (2,4) \to 1 \Rightarrow [C_{32} + g(2,4,1)] \Rightarrow 4 + 12 = \boxed{16}$

(d) $3 \to (4,2) \to 1 \Rightarrow [C_{34} + g(4,2,1)] \Rightarrow 12 + 17 = 29$

(e) $4 \to (2,3) \to 1 \Rightarrow [C_{42} + g(2,3,1)] \Rightarrow 10 + 12 = \boxed{22}$

(f) $4 \to (3,2) \to 1 \Rightarrow [C_{43} + g(3,2,1)] \Rightarrow 12 + 11 = 23$

(5) The final route can be :-

$$1 \to (2,3,4) \to 1 \Rightarrow \min [C_{12} + g(2\{3,4,1\}), \; C_{13} + g(3\{2,4,1\}), \; C_{14} + g(4\{2,3,1\})]$$

$$\Rightarrow \min [7 + 18, \; 8 + 16, \; 2 + 22] \Rightarrow \min [25, 24, 24] \Rightarrow 24$$

$\therefore$ The shortest path is 24 ; ie

$1 \to 3 \to 2 \to 4 \to 1$ and $1 \to 4 \to 2 \to 3 \to 1$

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