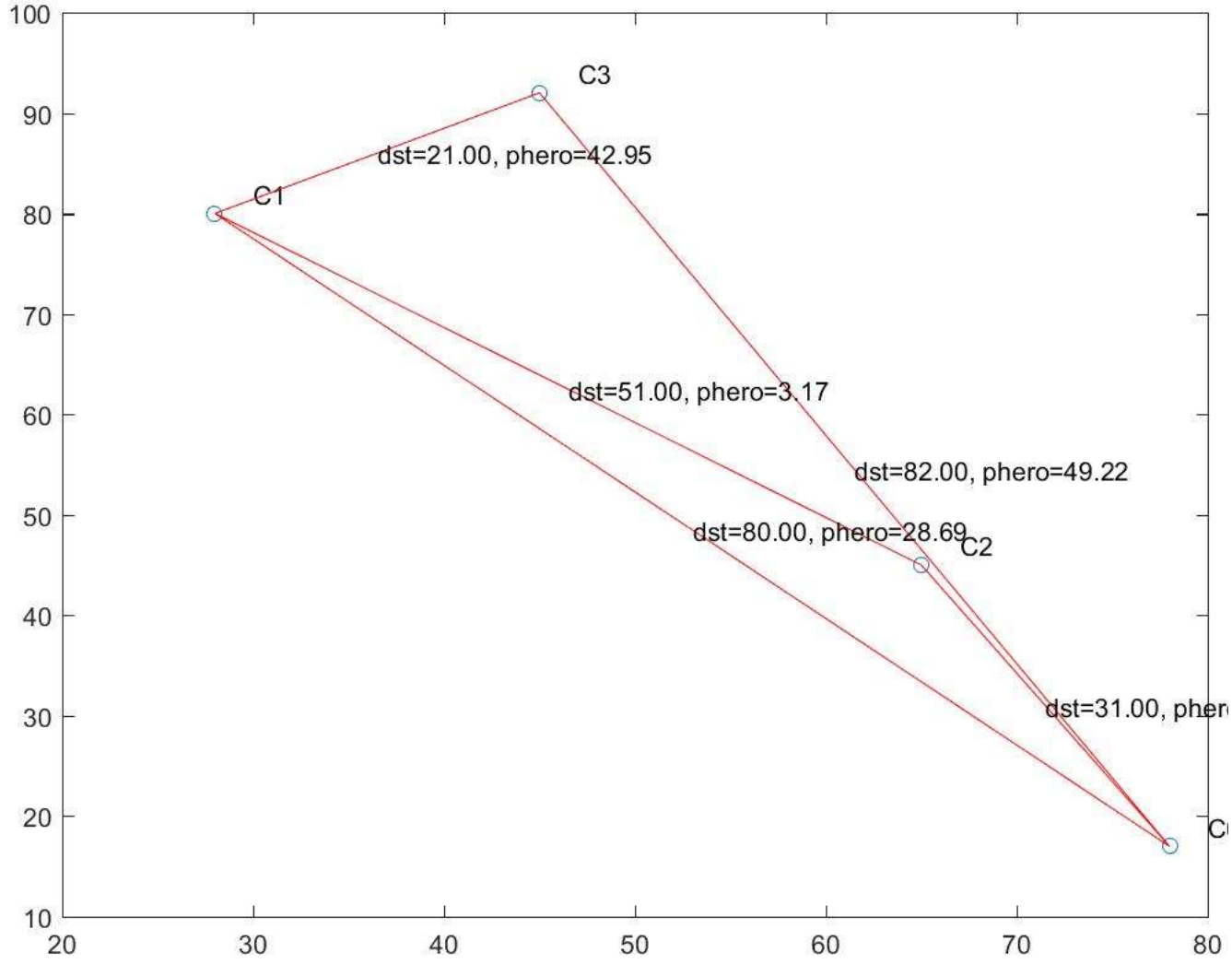
Question 1

At a given point of time and given an ant, the ant found 6 possible routes at its journey. The pheromone amounts on each route are :
9.000000 1.000000 9.000000 6.000000 1.000000 3.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
38.000000 67.000000 68.000000 11.000000 68.000000 67.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.5 and beta= 0.8

Answer
eta=1/d
eta1=0.026316
eta2=0.014925
eta3=0.014706
eta4=0.090909
eta5=0.014706
eta6=0.014925
P-1=0.216598
P-2=0.045867
P-3=0.135980
P-4=0.476784
P-5=0.045327
P-6=0.079444

Question 2

In a TSP problem with 4 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	80.00	31.00	82.00
C1	80.00	0.00	51.00	21.00
C2	31.00	51.00	0.00	51.00
C3	82.00	21.00	51.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	28.69	36.89	49.22
C1	28.69	0.00	3.17	42.95
C2	36.89	3.17	0.00	0.00
C3	49.22	42.95	0.00	0.00

- Assume that an ant has followed the following route:[0,3,1,2,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 2 steps in the above route assuming pheromone exponent parameter α=0.03 and heuristic exponent parameter β=0.94.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.30.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=11.82.

Answer

a. The cost of the aforementioned route:185.00

b. At node 0 the ant has 3 choices:From C0 to C1 the heuristic value is 0.01 and its pheromone value is 28.69 hence P=0.22
From C0 to C2 the heuristic value is 0.03 and its pheromone value is 36.89 hence P=0.55
From C0 to C3 the heuristic value is 0.01 and its pheromone value is 49.22 hence P=0.22
At node 3 the ant has 1 choices:From C3 to C1 the heuristic value is 0.05 and its pheromone value is 42.95 hence P=1.00
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**
C0	0.00	20.08	25.82	34.45
C1	20.08	0.00	2.22	30.07
C2	25.82	2.22	0.00	0.00
C3	34.45	30.07	0.00	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.06
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**
C0	0.00	20.08	25.82	34.52
C1	20.08	0.00	2.28	30.07
C2	25.89	2.22	0.00	0.00
C3	34.45	30.13	0.00	0.00

Question 3

Having the following rouing table at node 5

	N42	**N47**	**N75**	**N80**	**N10**
N17	0.23	0.32	0.33	0.14	0.21
N34	0.32	0.21	0.04	0.38	0.28
N6	0.44	0.33	0.13	0.05	0.39
N49	0.02	0.13	0.49	0.42	0.11

Having started at node 47 and reaching node 5 via node 17.Assuming it has been in the network for 9.051536 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.070000 and 0.050000 in order for ABC model

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δr=a/T+b
δr=0.057733
r1_2=(r1_2+δr)/(1+δr)
=0.360449
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N42	**N47**	**N75**	**N80**	**N10**
N17	0.23	0.36	0.33	0.14	0.21
N34	0.32	0.20	0.04	0.38	0.28
N6	0.44	0.31	0.13	0.05	0.39
N49	0.02	0.13	0.49	0.42	0.11

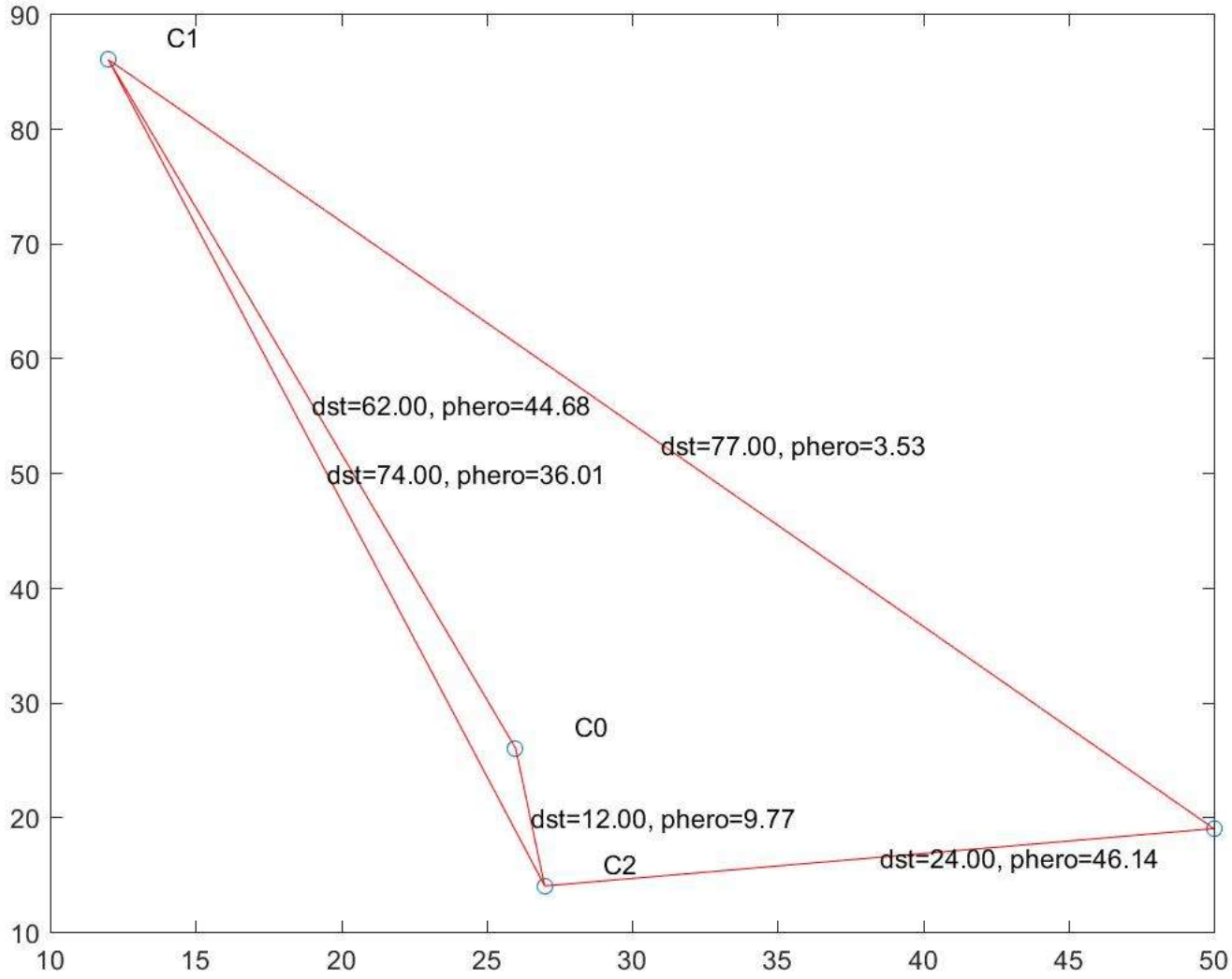
Question 4

At a given point of time and given an ant, the ant found 6 possible routes at its journey. The pheromone amounts on each route are :
1.000000 7.000000 7.000000 6.000000 2.000000 6.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
21.000000 9.000000 15.000000 63.000000 5.000000 17.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.1 and beta= 0.4

Answer
eta=1/d
eta1=0.047619
eta2=0.111111
eta3=0.066667
eta4=0.015873
eta5=0.200000
eta6=0.058824
P-1=0.123913
P-2=0.211261
P-3=0.172218
P-4=0.095518
P-5=0.235787
P-6=0.161303

Question 5

In a TSP problem with 4 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	62.00	12.00	25.00
C1	62.00	0.00	74.00	77.00
C2	12.00	74.00	0.00	24.00
C3	25.00	77.00	24.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	44.68	9.77	0.00
C1	44.68	0.00	36.01	3.53
C2	9.77	36.01	0.00	46.14
C3	0.00	3.53	46.14	0.00

- Assume that an ant has followed the following route:[1,0,2,3,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 3 steps in the above route assuming pheromone exponent parameter α=0.72 and heuristic exponent parameter β=0.84.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.43.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=18.82.

Answer

a. The cost of the aforementioned route:175.00
b. At node 1 the ant has 3 choices:From C1 to C2 the heuristic value is 0.01 and its pheromone value is 36.01 hence P=0.39
From C1 to C3 the heuristic value is 0.01 and its pheromone value is 3.53 hence P=0.07
From C1 to C0 the heuristic value is 0.02 and its pheromone value is 44.68 hence P=0.53
At node 0 the ant has 1 choices:From C0 to C2 the heuristic value is 0.08 and its pheromone value is 9.77 hence P=1.00
At node 2 the ant has 2 choices:From C2 to C3 the heuristic value is 0.04 and its pheromone value is 46.14 hence P=0.75
From C2 to C1 the heuristic value is 0.01 and its pheromone value is 36.01 hence P=0.25
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**
C0	0.00	25.47	5.57	0.00
C1	25.47	0.00	20.53	2.01
C2	5.57	20.53	0.00	26.30
C3	0.00	2.01	26.30	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.11
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**
C0	0.00	25.47	5.68	0.00
C1	25.58	0.00	20.53	2.01
C2	5.57	20.53	0.00	26.41
C3	0.00	2.12	26.30	0.00

Question 6

Having the following rouing table at node 5

	N90	**N60**	**N87**	**N92**	**N53**
N70	0.27	0.41	0.14	0.13	0.31
N55	0.13	0.20	0.30	0.02	0.33
N3	0.36	0.09	0.30	0.55	0.10
N42	0.24	0.30	0.26	0.30	0.27

Having started at node 92 and reaching node 5 via node 3.Assuming it has been in the network for 9.371347 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.080000 and 0.080000 in order for ABC model

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δr=a/T+b
δr=0.088537
r3_4=(r3_4+δr)/(1+δr)
=0.587682
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N90	**N60**	**N87**	**N92**	**N53**
N70	0.27	0.41	0.14	0.12	0.31
N55	0.13	0.20	0.30	0.02	0.33
N3	0.36	0.09	0.30	0.59	0.10
N42	0.24	0.30	0.26	0.27	0.27

Question 7

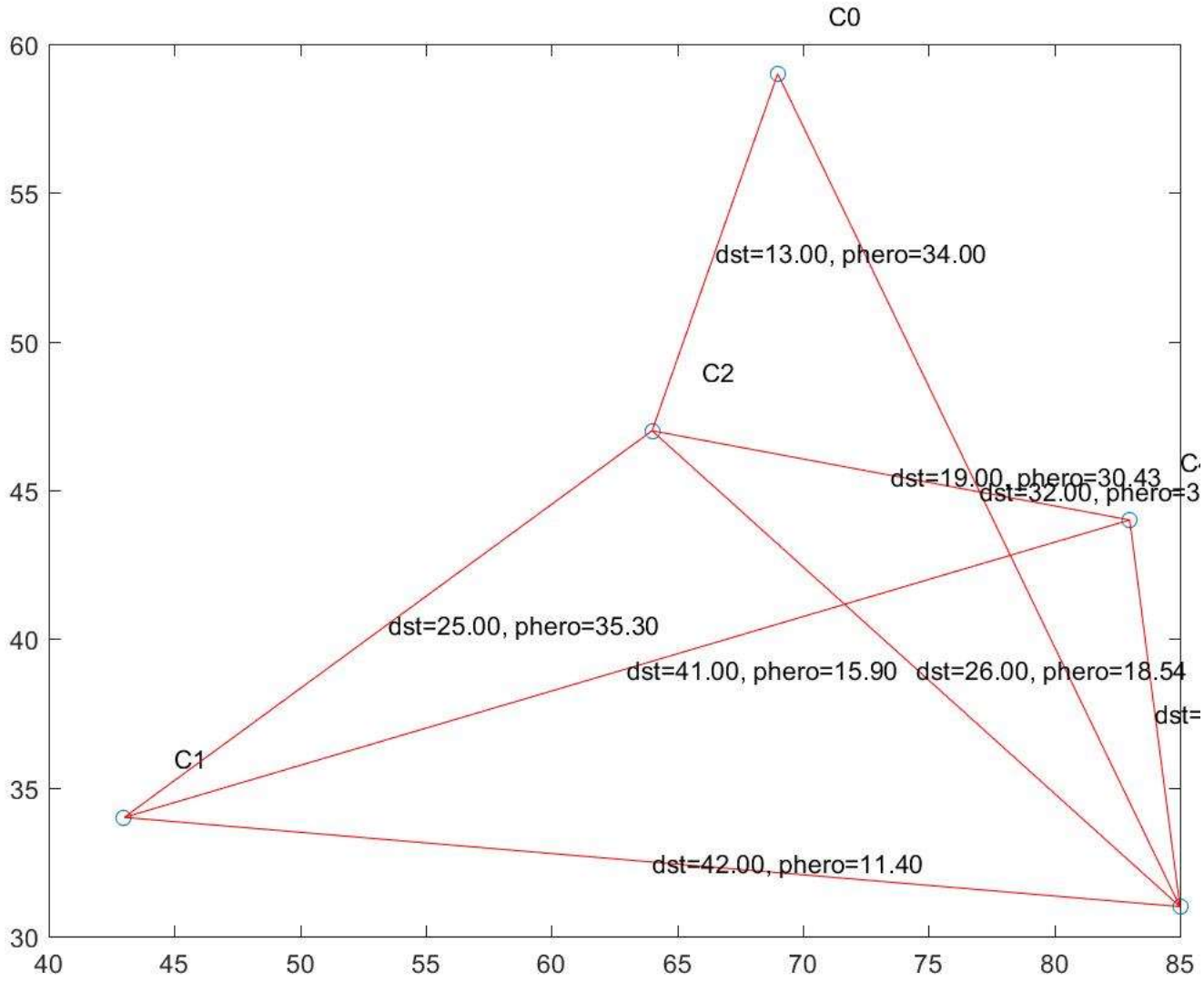
At a given point of time and given an ant, the ant found 4 possible routes at its journey. The pheromone amounts on each route are :
6.000000 9.000000 9.000000 7.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
14.000000 46.000000 5.000000 28.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.7 and beta= 0.9

Answer
eta=1/d
eta1=0.071429
eta2=0.021739
eta3=0.200000
eta4=0.035714
P-1=0.184933
P-2=0.084200
P-3=0.620471

P-4=0.110395

Question 8

In a TSP problem with 5 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	C1	C2	C3	C4
C0	0.00	36.00	13.00	32.00	21.00
C1	36.00	0.00	25.00	42.00	41.00
C2	13.00	25.00	0.00	26.00	19.00
C3	32.00	42.00	26.00	0.00	13.00
C4	21.00	41.00	19.00	13.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	C1	C2	C3	C4
C0	0.00	0.00	34.00	38.62	0.00
C1	0.00	0.00	35.30	11.40	15.90
C2	34.00	35.30	0.00	18.54	30.43
C3	38.62	11.40	18.54	0.00	45.51
C4	0.00	15.90	30.43	45.51	0.00

- Assume that an ant has followed the following route:[2,4,1,3,0,] and back to source

  a. Calculate the total cost of the above route.

b. Calculate the ant's switching probabilities for the first 2 steps in the above route assuming pheromone exponent parameter α=0.85 and heuristic exponent parameter β=0.44.
c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.90.
d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=1.33.

Answer

a. The cost of the aforementioned route:147.00
b. At node 2 the ant has 4 choices:From C2 to C3 the heuristic value is 0.04 and its pheromone value is 18.54 hence P=0.15
From C2 to C4 the heuristic value is 0.05 and its pheromone value is 30.43 hence P=0.26
From C2 to C0 the heuristic value is 0.08 and its pheromone value is 34.00 hence P=0.34
From C2 to C1 the heuristic value is 0.04 and its pheromone value is 35.30 hence P=0.26
At node 4 the ant has 2 choices:From C4 to C1 the heuristic value is 0.02 and its pheromone value is 15.90 hence P=0.20
From C4 to C3 the heuristic value is 0.08 and its pheromone value is 45.51 hence P=0.80
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	C1	C2	C3	C4
C0	0.00	0.00	3.40	3.86	0.00
C1	0.00	0.00	3.53	1.14	1.59
C2	3.40	3.53	0.00	1.85	3.04
C3	3.86	1.14	1.85	0.00	4.55
C4	0.00	1.59	3.04	4.55	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.01
The updated Pheromone matrix:

	C0	C1	C2	C3	C4
C0	0.00	0.00	3.41	3.86	0.00
C1	0.00	0.00	3.53	1.15	1.59
C2	3.40	3.53	0.00	1.85	3.05
C3	3.87	1.14	1.85	0.00	4.55
C4	0.00	1.60	3.04	4.55	0.00

Question 9

Having the following rouing table at node 5

	N19	N1	N32	N68	N61
N52	0.30	0.13	0.04	0.11	0.39
N42	0.41	0.22	0.49	0.07	0.35
N27	0.10	0.28	0.25	0.42	0.08
N47	0.19	0.38	0.22	0.41	0.17

Having started at node 68 and reaching node 5 via node 47.Assuming it has been in the network for 7.476628 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.060000 and 0.020000 in order for ABC model

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δr=a/T+b
δr=0.028025
r4_4=(r4_4+δr)/(1+δr)
=0.424816
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N19	N1	N32	N68	N61
N52	0.30	0.13	0.04	0.10	0.39
N42	0.41	0.22	0.49	0.07	0.35
N27	0.10	0.28	0.25	0.41	0.08
N47	0.19	0.38	0.22	0.42	0.17

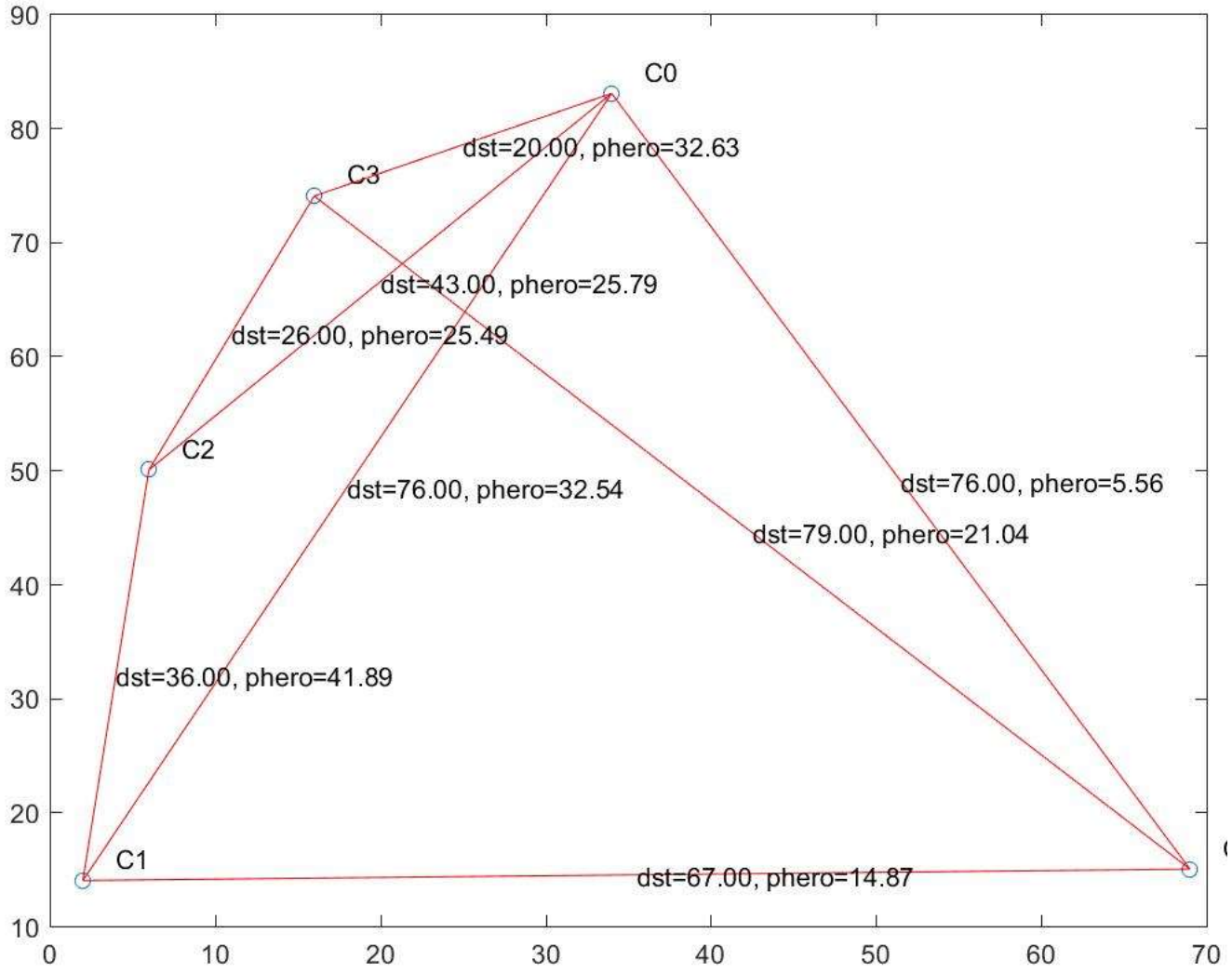
Question 10

At a given point of time and given an ant, the ant found 5 possible routes at its journey. The pheromone amounts on each route are :
3.000000 1.000000 1.000000 2.000000 7.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
30.000000 49.000000 18.000000 1.000000 37.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.3 and beta= 0.9

Answer
eta=1/d
eta1=0.033333
eta2=0.020408
eta3=0.055556
eta4=1.000000
eta5=0.027027
P-1=0.044298
P-2=0.020487
P-3=0.050456
P-4=0.837465
P-5=0.047294

Question 11

In a TSP problem with 5 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	C1	C2	C3	C4
C0	0.00	76.00	43.00	20.00	76.00
C1	76.00	0.00	36.00	62.00	67.00
C2	43.00	36.00	0.00	26.00	72.00
C3	20.00	62.00	26.00	0.00	79.00
C4	76.00	67.00	72.00	79.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	C1	C2	C3	C4

C0	0.00	32.54	25.79	32.63	5.56
C1	32.54	0.00	41.89	0.00	14.87
C2	25.79	41.89	0.00	25.49	0.00
C3	32.63	0.00	25.49	0.00	21.04
C4	5.56	14.87	0.00	21.04	0.00

- Assume that an ant has followed the following route:[3,2,1,0,4,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 1 steps in the above route assuming pheromone exponent parameter α=0.40 and heuristic exponent parameter β=0.30.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.31.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=4.22.

Answer

a. The cost of the aforementioned route:293.00
b. At node 3 the ant has 3 choices:From C3 to C4 the heuristic value is 0.01 and its pheromone value is 21.04 hence P=0.23
From C3 to C0 the heuristic value is 0.05 and its pheromone value is 32.63 hence P=0.42
From C3 to C2 the heuristic value is 0.04 and its pheromone value is 25.49 hence P=0.35
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	22.45	17.80	22.51	3.84
C1	22.45	0.00	28.90	0.00	10.26
C2	17.80	28.90	0.00	17.59	0.00
C3	22.51	0.00	17.59	0.00	14.52
C4	3.84	10.26	0.00	14.52	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.01
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	22.45	17.80	22.51	3.85
C1	22.47	0.00	28.90	0.00	10.26
C2	17.80	28.92	0.00	17.59	0.00
C3	22.51	0.00	17.60	0.00	14.52
C4	3.84	10.26	0.00	14.53	0.00

Question 12

Having the following rouing table at node 5

	N52	**N98**	**N49**	**N68**	**N40**
N4	0.58	0.16	0.34	0.47	0.11
N28	0.27	0.32	0.05	0.07	0.37
N75	0.15	0.50	0.31	0.26	0.39
N32	0.00	0.02	0.30	0.21	0.14

Having started at node 52 and reaching node 5 via node 75.Assuming it has been in the network for 7.394795 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.050000 and 0.080000 in order for ABC model

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$\delta r=a/T+b$
$\delta r=0.086762$
r3_1=(r3_1+δr)/(1+δr)
=0.218177
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N52	**N98**	**N49**	**N68**	**N40**
N4	0.53	0.16	0.34	0.47	0.11
N28	0.25	0.32	0.05	0.07	0.37
N75	0.22	0.50	0.31	0.26	0.39
N32	0.00	0.02	0.30	0.21	0.14

Question 13

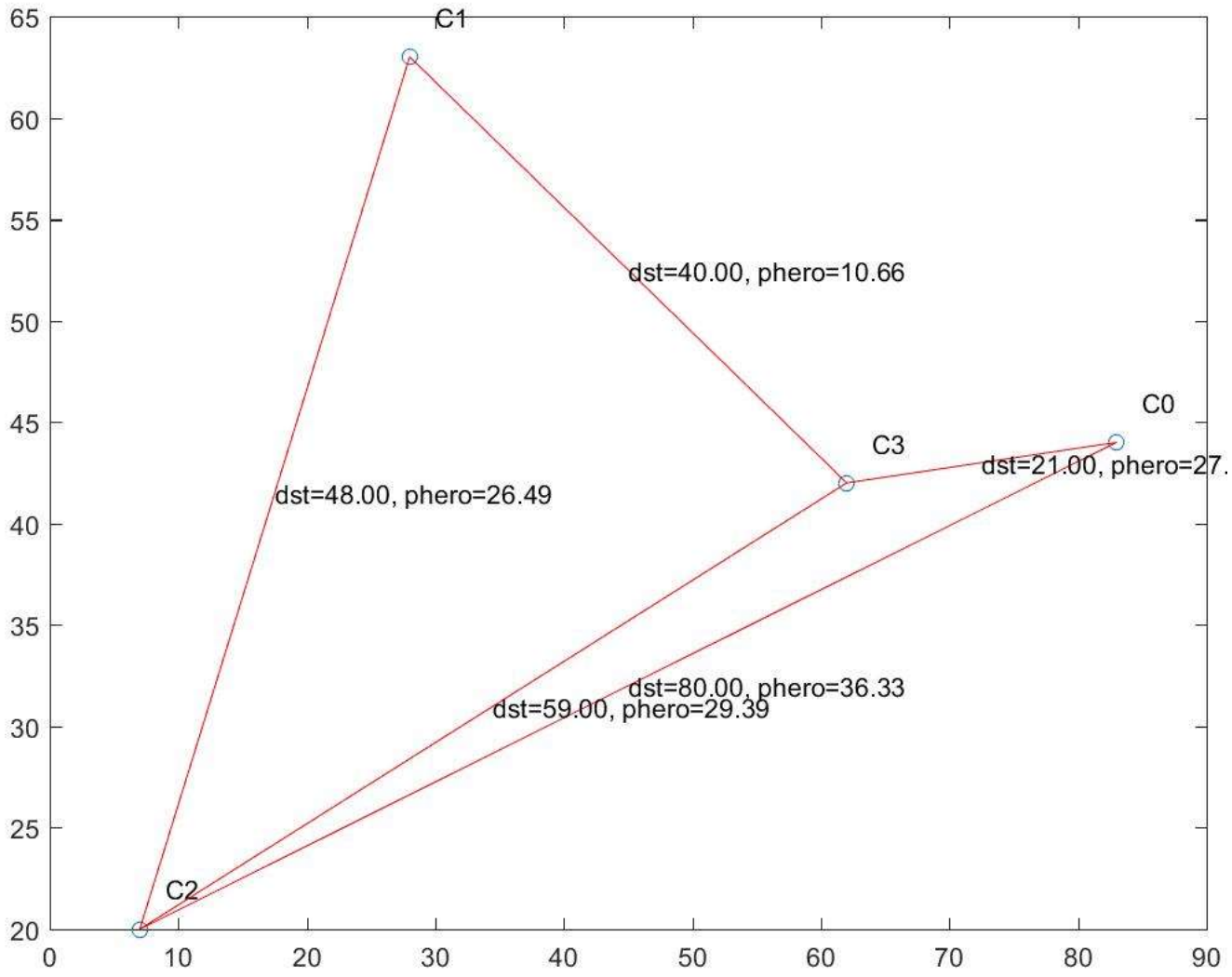
At a given point of time and given an ant, the ant found 6 possible routes at its journey. The pheromone amounts on each route are :

2.000000 1.000000 8.000000 6.000000 0.000000 9.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
36.000000 38.000000 42.000000 53.000000 60.000000 27.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.1 and beta= 0.7

Answer
eta=1/d
eta1=0.027778
eta2=0.026316
eta3=0.023810
eta4=0.018868
eta5=0.016667
eta6=0.037037
P-1=0.192212
P-2=0.172680
P-3=0.198210
P-4=0.163649
P-5=0.000000
P-6=0.273250

Question 14

In a TSP problem with 4 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	C1	C2	C3
C0	0.00	58.00	80.00	21.00
C1	58.00	0.00	48.00	40.00

C2	80.00	48.00	0.00	59.00
C3	21.00	40.00	59.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	0.00	36.33	27.60
C1	0.00	0.00	26.49	10.66
C2	36.33	26.49	0.00	29.39
C3	27.60	10.66	29.39	0.00

- Assume that an ant has followed the following route:[0,2,1,3,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 3 steps in the above route assuming pheromone exponent parameter α=0.22 and heuristic exponent parameter β=0.41.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.63.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=22.21.

Answer

a. The cost of the aforementioned route:189.00
b. At node 0 the ant has 2 choices:From C0 to C2 the heuristic value is 0.01 and its pheromone value is 36.33 hence P=0.38
From C0 to C3 the heuristic value is 0.05 and its pheromone value is 27.60 hence P=0.62
At node 2 the ant has 2 choices:From C2 to C3 the heuristic value is 0.02 and its pheromone value is 29.39 hence P=0.48
From C2 to C1 the heuristic value is 0.02 and its pheromone value is 26.49 hence P=0.52
At node 1 the ant has 1 choices:From C1 to C3 the heuristic value is 0.03 and its pheromone value is 10.66 hence P=1.00
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**
C0	0.00	0.00	13.44	10.21
C1	0.00	0.00	9.80	3.94
C2	13.44	9.80	0.00	10.87
C3	10.21	3.94	10.87	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.12
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**
C0	0.00	0.00	13.56	10.21
C1	0.00	0.00	9.80	4.06
C2	13.44	9.92	0.00	10.87
C3	10.33	3.94	10.87	0.00

Question 15

Having the following rouing table at node 5

	N91	**N68**	**N38**	**N62**	**N24**
N55	0.18	0.37	0.06	0.20	0.45
N93	0.24	0.12	0.46	0.35	0.34
N80	0.00	0.50	0.47	0.10	0.00
N27	0.58	0.01	0.01	0.34	0.21

Having started at node 62 and reaching node 5 via node 93.Assuming it has been in the network for 0.839863 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.030000 and 0.080000 in order for ABC model

---

$\delta r=a/T+b$
$\delta r=0.115720$
$r2\_4=(r2\_4+\delta r)/(1+\delta r)$
=0.421434
The remaining cells in the source column will be updated by $rks/(1+\delta r)$
The updated table will be:

	N91	**N68**	**N38**	**N62**	**N24**
N55	0.18	0.37	0.06	0.18	0.45
N93	0.24	0.12	0.46	0.42	0.34
N80	0.00	0.50	0.47	0.09	0.00
N27	0.58	0.01	0.01	0.31	0.21

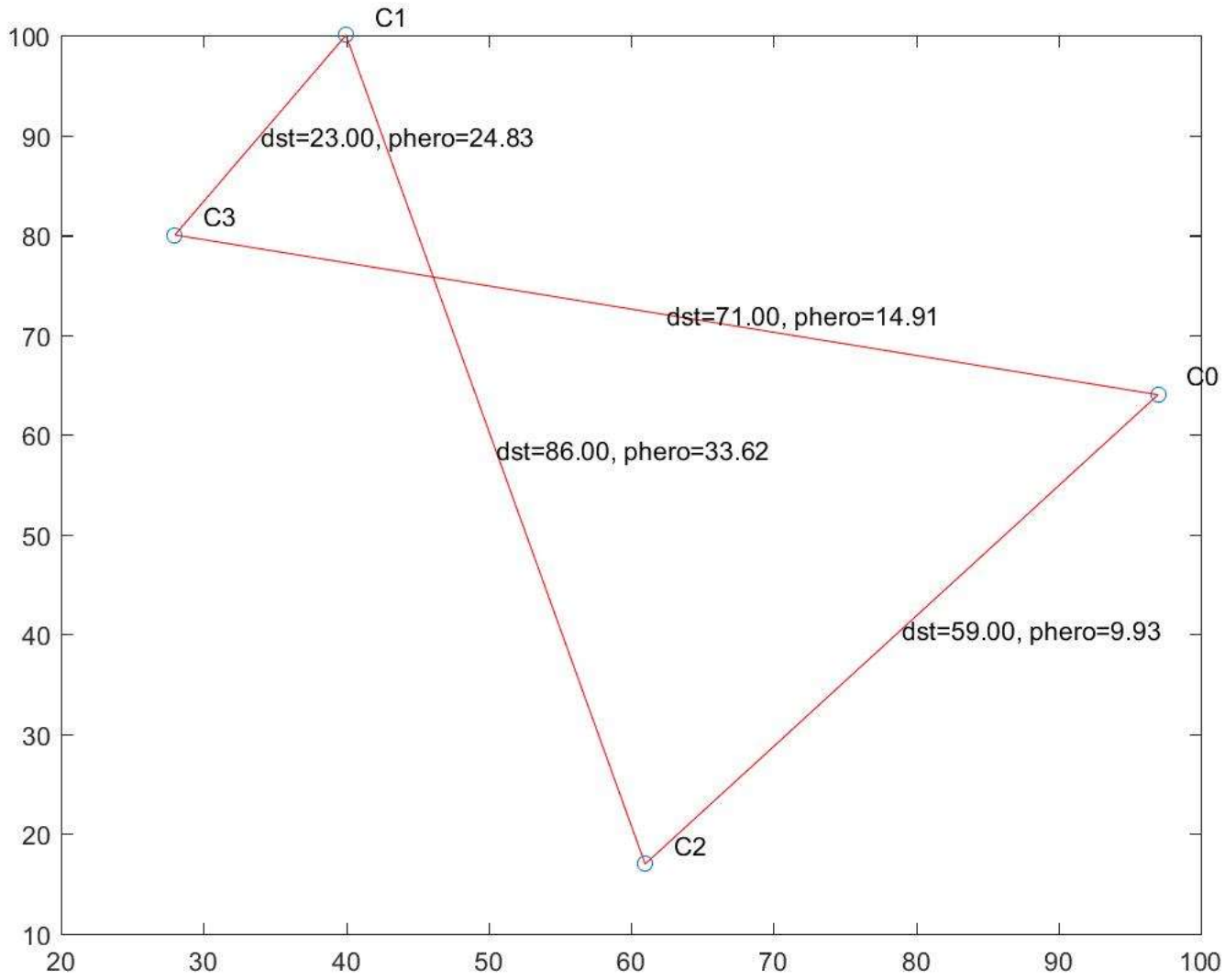
Question 16

At a given point of time and given an ant, the ant found 3 possible routes at its journey. The pheromone amounts on each route are :
5.000000 8.000000 7.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
10.000000 31.000000 25.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.5 and beta= 0.6

Answer
eta=1/d
eta1=0.100000
eta2=0.032258
eta3=0.040000
P-1=0.430223
P-2=0.276017
P-3=0.293760

Question 17

In a TSP problem with 4 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	67.00	59.00	71.00
C1	67.00	0.00	86.00	23.00
C2	59.00	86.00	0.00	71.00

C3	71.00	23.00	71.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	0.00	9.93	14.91
C1	0.00	0.00	33.62	24.83
C2	9.93	33.62	0.00	0.00
C3	14.91	24.83	0.00	0.00

- Assume that an ant has followed the following route:[1,2,0,3,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 3 steps in the above route assuming pheromone exponent parameter α=0.41 and heuristic exponent parameter β=0.01.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.70.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=20.27.

Answer

a. The cost of the aforementioned route:239.00
b. At node 1 the ant has 2 choices:From C1 to C2 the heuristic value is 0.01 and its pheromone value is 33.62 hence P=0.53
From C1 to C3 the heuristic value is 0.04 and its pheromone value is 24.83 hence P=0.47
At node 2 the ant has 1 choices:From C2 to C0 the heuristic value is 0.02 and its pheromone value is 9.93 hence P=1.00
At node 0 the ant has 1 choices:From C0 to C3 the heuristic value is 0.01 and its pheromone value is 14.91 hence P=1.00
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**
C0	0.00	0.00	2.98	4.47
C1	0.00	0.00	10.09	7.45
C2	2.98	10.09	0.00	0.00
C3	4.47	7.45	0.00	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.08
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**
C0	0.00	0.00	2.98	4.56
C1	0.00	0.00	10.17	7.45
C2	3.06	10.09	0.00	0.00
C3	4.47	7.53	0.00	0.00

Question 18

Having the following rouing table at node 5

	N69	**N14**	**N51**	**N70**	**N90**
N97	0.37	0.14	0.17	0.20	0.05
N71	0.06	0.56	0.35	0.20	0.65
N38	0.35	0.27	0.07	0.13	0.11
N23	0.23	0.04	0.41	0.47	0.20

Having started at node 51 and reaching node 5 via node 97.Assuming it has been in the network for 6.629329 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.080000 and 0.080000 in order for ABC model

---

δr=a/T+b
δr=0.092068
r1_3=(r1_3+δr)/(1+δr)
=0.238480
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N69	**N14**	**N51**	**N70**	**N90**
N97	0.37	0.14	0.24	0.20	0.05
N71	0.06	0.56	0.32	0.20	0.65
N38	0.35	0.27	0.07	0.13	0.11
N23	0.23	0.04	0.37	0.47	0.20

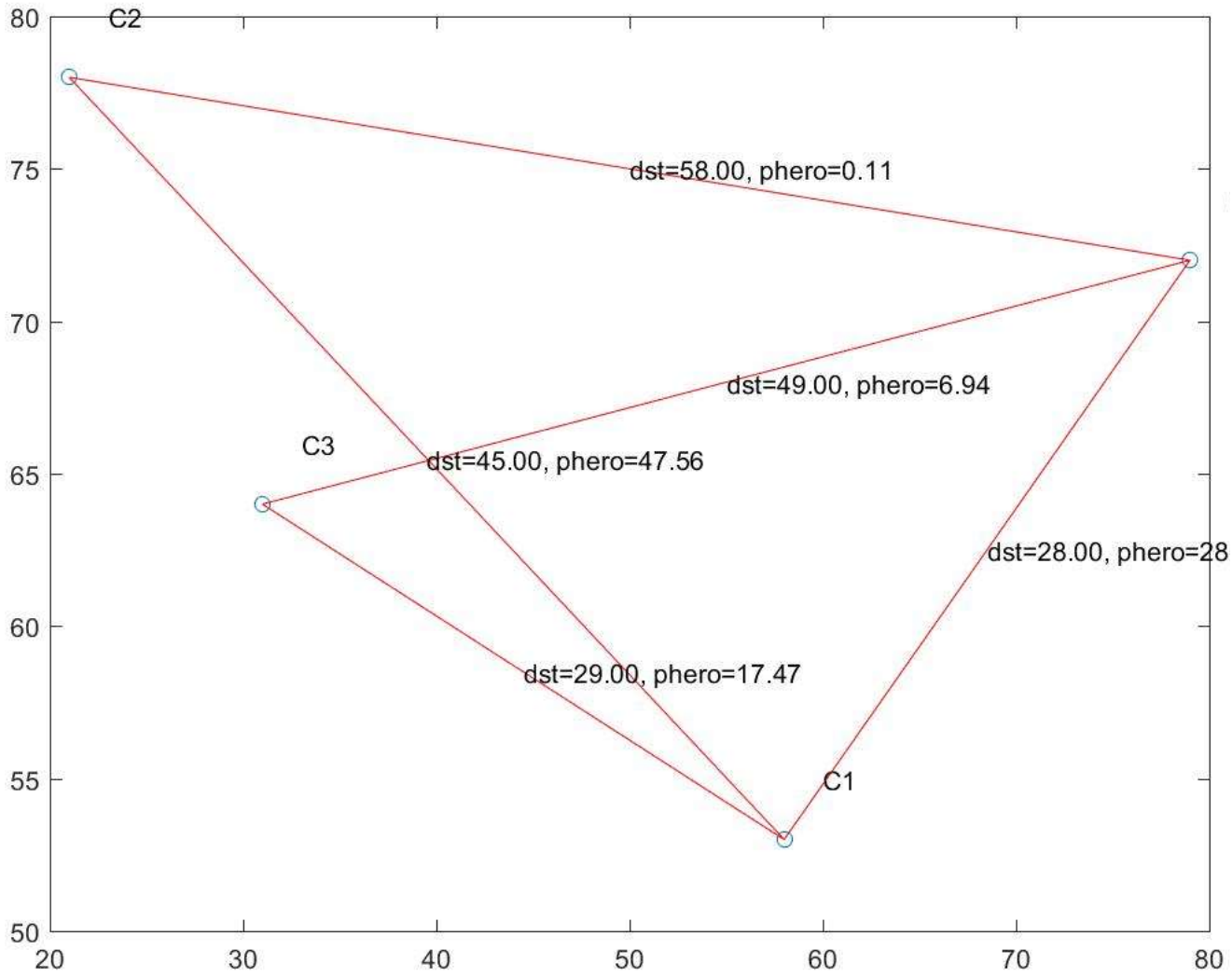
Question 19

At a given point of time and given an ant, the ant found 4 possible routes at its journey. The pheromone amounts on each route are :
3.000000 7.000000 10.000000 8.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
58.000000 49.000000 42.000000 53.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.5 and beta= 0.9

Answer
eta=1/d
eta1=0.017241
eta2=0.020408
eta3=0.023810
eta4=0.018868
P-1=0.143060
P-2=0.254341
P-3=0.349237
P-4=0.253362

Question 20

In a TSP problem with 4 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	C1	C2	C3
C0	0.00	28.00	58.00	49.00
C1	28.00	0.00	45.00	29.00
C2	58.00	45.00	0.00	17.00
C3	49.00	29.00	17.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	C1	C2	C3
C0	0.00	28.25	0.11	6.94
C1	28.25	0.00	47.56	17.47
C2	0.11	47.56	0.00	0.00
C3	6.94	17.47	0.00	0.00

- Assume that an ant has followed the following route:[3,0,2,1,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 3 steps in the above route assuming pheromone exponent parameter α=0.64 and heuristic exponent parameter β=0.73.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.86.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=25.08.

Answer

a. The cost of the aforementioned route:181.00
b. At node 3 the ant has 2 choices:From C3 to C0 the heuristic value is 0.02 and its pheromone value is 6.94 hence P=0.27
From C3 to C1 the heuristic value is 0.03 and its pheromone value is 17.47 hence P=0.73
At node 0 the ant has 2 choices:From C0 to C1 the heuristic value is 0.04 and its pheromone value is 28.25 hence P=0.98
From C0 to C2 the heuristic value is 0.02 and its pheromone value is 0.11 hence P=0.02
At node 2 the ant has 1 choices:From C2 to C1 the heuristic value is 0.02 and its pheromone value is 47.56 hence P=1.00
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	C1	C2	C3
C0	0.00	3.96	0.02	0.97
C1	3.96	0.00	6.66	2.45
C2	0.02	6.66	0.00	0.00
C3	0.97	2.45	0.00	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.14
The updated Pheromone matrix:

	C0	C1	C2	C3
C0	0.00	3.96	0.15	0.97
C1	3.96	0.00	6.66	2.58
C2	0.02	6.80	0.00	0.00
C3	1.11	2.45	0.00	0.00

Question 21

Having the following rouing table at node 5

	N96	N2	N94	N3	N98
N29	0.10	0.05	0.35	0.09	0.26
N50	0.31	0.23	0.23	0.39	0.24
N81	0.09	0.39	0.10	0.38	0.21
N83	0.50	0.32	0.31	0.14	0.29

Having started at node 96 and reaching node 5 via node 81.Assuming it has been in the network for 9.757071 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.010000 and 0.020000 in order for ABC model

---

δr=a/T+b
δr=0.021025
r3_1=(r3_1+δr)/(1+δr)
=0.108443
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N96	N2	N94	N3	N98
N29	0.10	0.05	0.35	0.09	0.26
N50	0.31	0.23	0.23	0.39	0.24
N81	0.11	0.39	0.10	0.38	0.21
N83	0.49	0.32	0.31	0.14	0.29

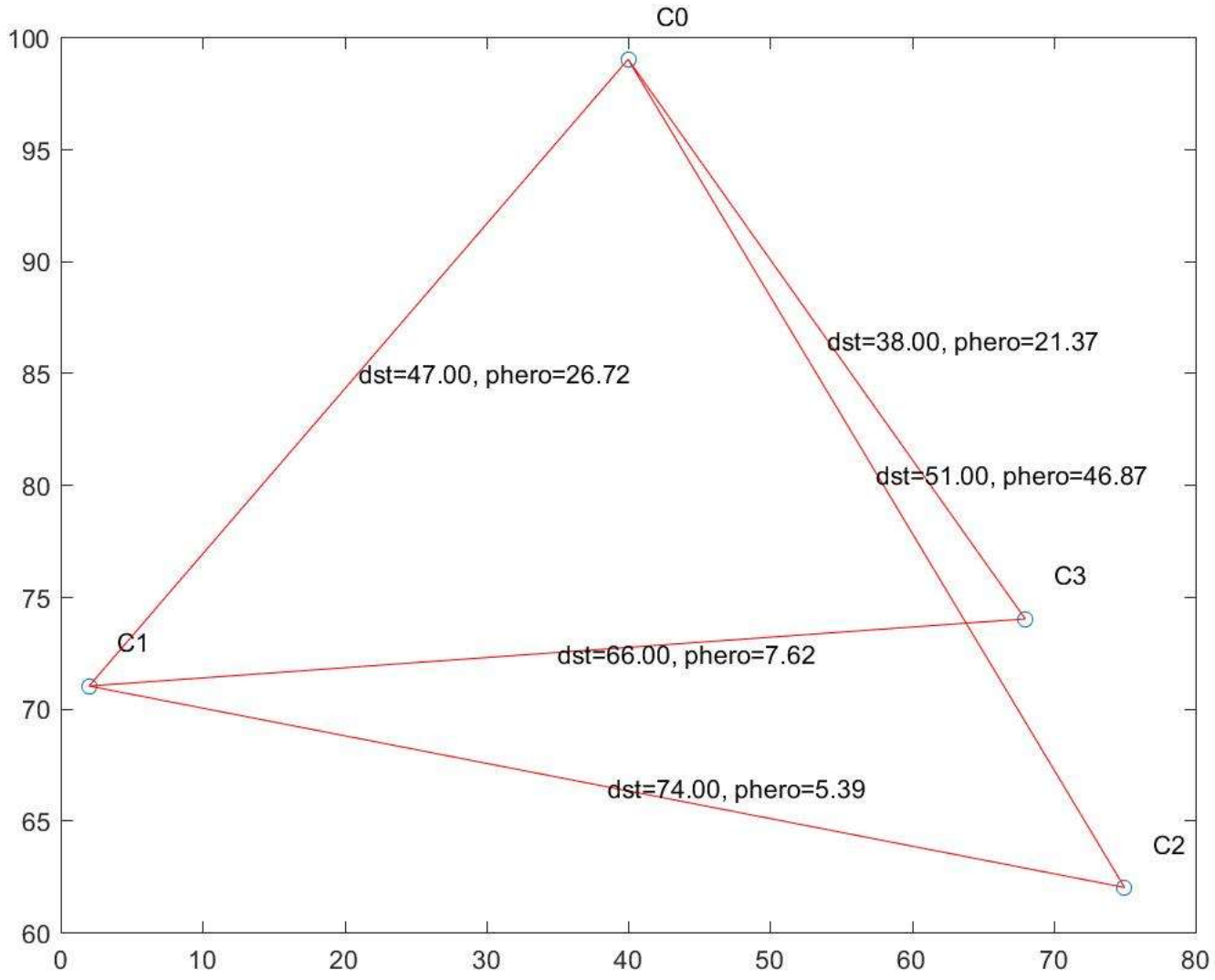
Question 22

At a given point of time and given an ant, the ant found 5 possible routes at its journey. The pheromone amounts on each route are :
0.000000 1.000000 5.000000 8.000000 10.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
0.000000 38.000000 60.000000 64.000000 59.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.9 and beta= 0.7

Answer
eta=1/d
eta1=Inf
eta2=0.026316
eta3=0.016667
eta4=0.015625
eta5=0.016949
P-1=NaN
P-2=NaN
P-3=NaN
P-4=NaN
P-5=NaN

Question 23

In a TSP problem with 4 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	C1	C2	C3
C0	0.00	47.00	51.00	38.00
C1	47.00	0.00	74.00	66.00

C2	51.00	74.00	0.00	14.00
C3	38.00	66.00	14.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**
C0	0.00	26.72	46.87	21.37
C1	26.72	0.00	5.39	7.62
C2	46.87	5.39	0.00	0.00
C3	21.37	7.62	0.00	0.00

- Assume that an ant has followed the following route:[2,0,3,1,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 2 steps in the above route assuming pheromone exponent parameter α=0.88 and heuristic exponent parameter β=0.73.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.41.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=24.17.

Answer

a. The cost of the aforementioned route:229.00
b. At node 2 the ant has 2 choices:From C2 to C0 the heuristic value is 0.02 and its pheromone value is 46.87 hence P=0.90
From C2 to C1 the heuristic value is 0.01 and its pheromone value is 5.39 hence P=0.10
At node 0 the ant has 2 choices:From C0 to C1 the heuristic value is 0.02 and its pheromone value is 26.72 hence P=0.51
From C0 to C3 the heuristic value is 0.03 and its pheromone value is 21.37 hence P=0.49
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**
C0	0.00	15.76	27.65	12.61
C1	15.76	0.00	3.18	4.50
C2	27.65	3.18	0.00	0.00
C3	12.61	4.50	0.00	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.11
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**
C0	0.00	15.76	27.65	12.71
C1	15.76	0.00	3.29	4.50
C2	27.76	3.18	0.00	0.00
C3	12.61	4.60	0.00	0.00

Question 24

Having the following rouing table at node 5

	N85	**N91**	**N2**	**N51**	**N63**
N37	0.41	0.29	0.38	0.31	0.05
N62	0.08	0.48	0.37	0.20	0.44
N71	0.31	0.22	0.14	0.22	0.47
N53	0.20	0.02	0.11	0.27	0.05

Having started at node 51 and reaching node 5 via node 62.Assuming it has been in the network for 4.268350 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.060000 and 0.080000 in order for ABC model

---

δr=a/T+b
δr=0.094057
r2_4=(r2_4+δr)/(1+δr)
=0.269649
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N85	**N91**	**N2**	**N51**	**N63**
N37	0.41	0.29	0.38	0.28	0.05
N62	0.08	0.48	0.37	0.27	0.44
N71	0.31	0.22	0.14	0.20	0.47
N53	0.20	0.02	0.11	0.25	0.05

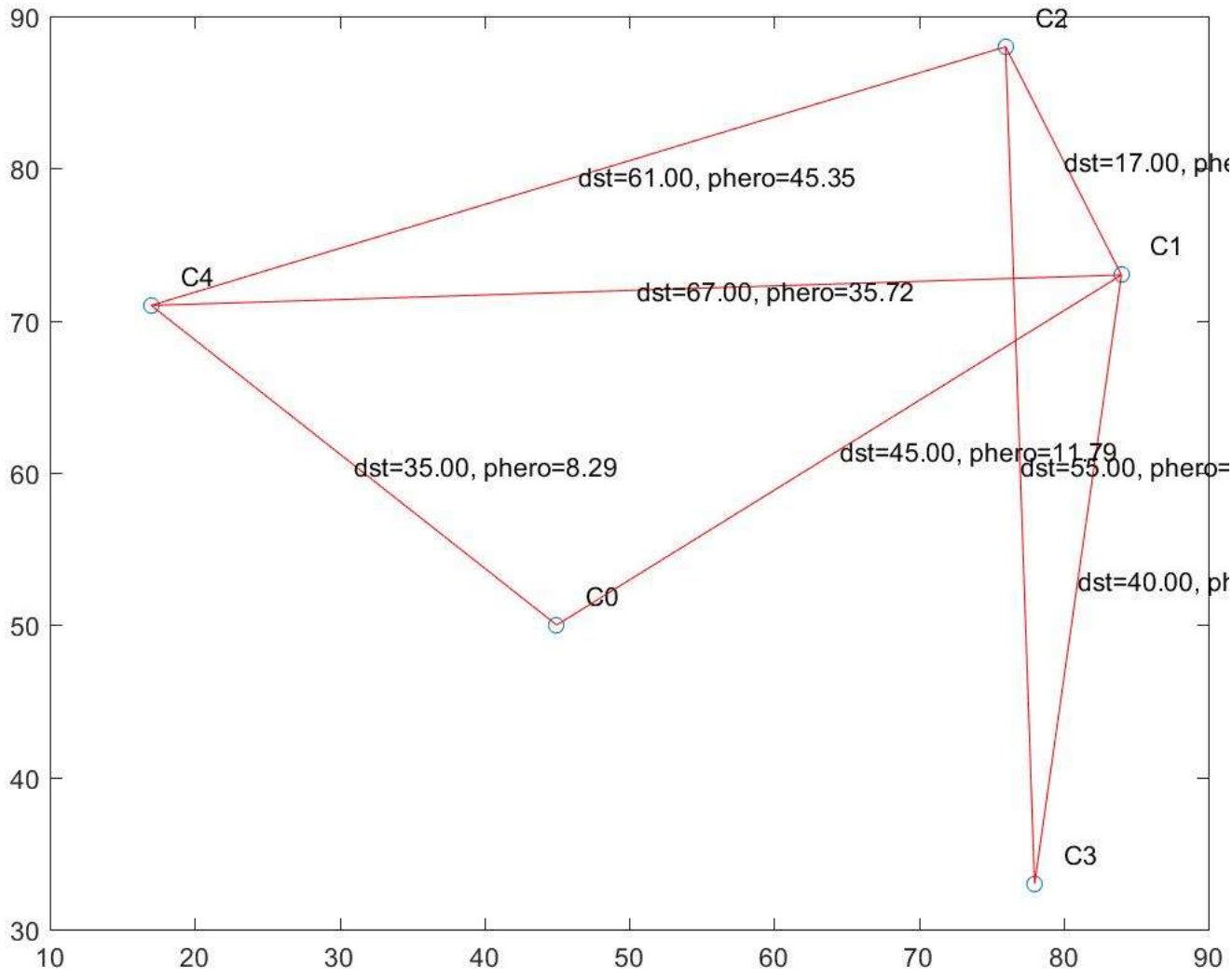
Question 25

At a given point of time and given an ant, the ant found 4 possible routes at its journey. The pheromone amounts on each route are :
4.000000 6.000000 4.000000 1.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
52.000000 2.000000 30.000000 3.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=1.0 and beta= 0.5

Answer
eta=1/d
eta1=0.019231
eta2=0.500000
eta3=0.033333
eta4=0.333333
P-1=0.090860
P-2=0.694947
P-3=0.119623
P-4=0.094570

Question 26

In a TSP problem with 5 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	C1	C2	C3	C4
C0	0.00	45.00	49.00	37.00	35.00
C1	45.00	0.00	17.00	40.00	67.00

C2	49.00	17.00	0.00	55.00	61.00
C3	37.00	40.00	55.00	0.00	72.00
C4	35.00	67.00	61.00	72.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	11.79	0.00	0.00	8.29
C1	11.79	0.00	16.37	8.70	35.72
C2	0.00	16.37	0.00	31.37	45.35
C3	0.00	8.70	31.37	0.00	0.00
C4	8.29	35.72	45.35	0.00	0.00

- Assume that an ant has followed the following route:[1,0,4,2,3,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 5 steps in the above route assuming pheromone exponent parameter α=0.86 and heuristic exponent parameter β=0.52.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.48.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=35.60.

Answer

a. The cost of the aforementioned route:236.00
b. At node 1 the ant has 4 choices:From C1 to C2 the heuristic value is 0.06 and its pheromone value is 16.37 hence P=0.36
From C1 to C3 the heuristic value is 0.03 and its pheromone value is 8.70 hence P=0.13
From C1 to C4 the heuristic value is 0.01 and its pheromone value is 35.72 hence P=0.34
From C1 to C0 the heuristic value is 0.02 and its pheromone value is 11.79 hence P=0.16
At node 0 the ant has 1 choices:From C0 to C4 the heuristic value is 0.03 and its pheromone value is 8.29 hence P=1.00
At node 4 the ant has 2 choices:From C4 to C1 the heuristic value is 0.01 and its pheromone value is 35.72 hence P=0.44
From C4 to C2 the heuristic value is 0.02 and its pheromone value is 45.35 hence P=0.56
At node 2 the ant has 2 choices:From C2 to C3 the heuristic value is 0.02 and its pheromone value is 31.37 hence P=0.49
From C2 to C1 the heuristic value is 0.06 and its pheromone value is 16.37 hence P=0.51
At node 3 the ant has 1 choices:From C3 to C1 the heuristic value is 0.03 and its pheromone value is 8.70 hence P=1.00
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	6.13	0.00	0.00	4.31
C1	6.13	0.00	8.51	4.52	18.57
C2	0.00	8.51	0.00	16.31	23.58
C3	0.00	4.52	16.31	0.00	0.00
C4	4.31	18.57	23.58	0.00	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.15
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	6.13	0.00	0.00	4.46
C1	6.28	0.00	8.51	4.52	18.57
C2	0.00	8.51	0.00	16.46	23.58
C3	0.00	4.67	16.31	0.00	0.00
C4	4.31	18.57	23.73	0.00	0.00

Question 27

Having the following rouing table at node 5

	N14	**N71**	**N46**	**N11**	**N68**
N18	0.03	0.20	0.36	0.08	0.46
N76	0.26	0.02	0.14	0.22	0.27
N48	0.32	0.12	0.37	0.33	0.14
N51	0.38	0.66	0.12	0.37	0.13

Having started at node 71 and reaching node 5 via node 51.Assuming it has been in the network for 5.710234 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.040000 and 0.070000 in order for ABC model

---

$\delta r=a/T+b$
$\delta r=0.077005$
$r4\_2=(r4\_2+\delta r)/(1+\delta r)$

=0.687244
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N14	**N71**	**N46**	**N11**	**N68**
N18	0.03	0.18	0.36	0.08	0.46
N76	0.26	0.02	0.14	0.22	0.27
N48	0.32	0.11	0.37	0.33	0.14
N51	0.38	0.69	0.12	0.37	0.13

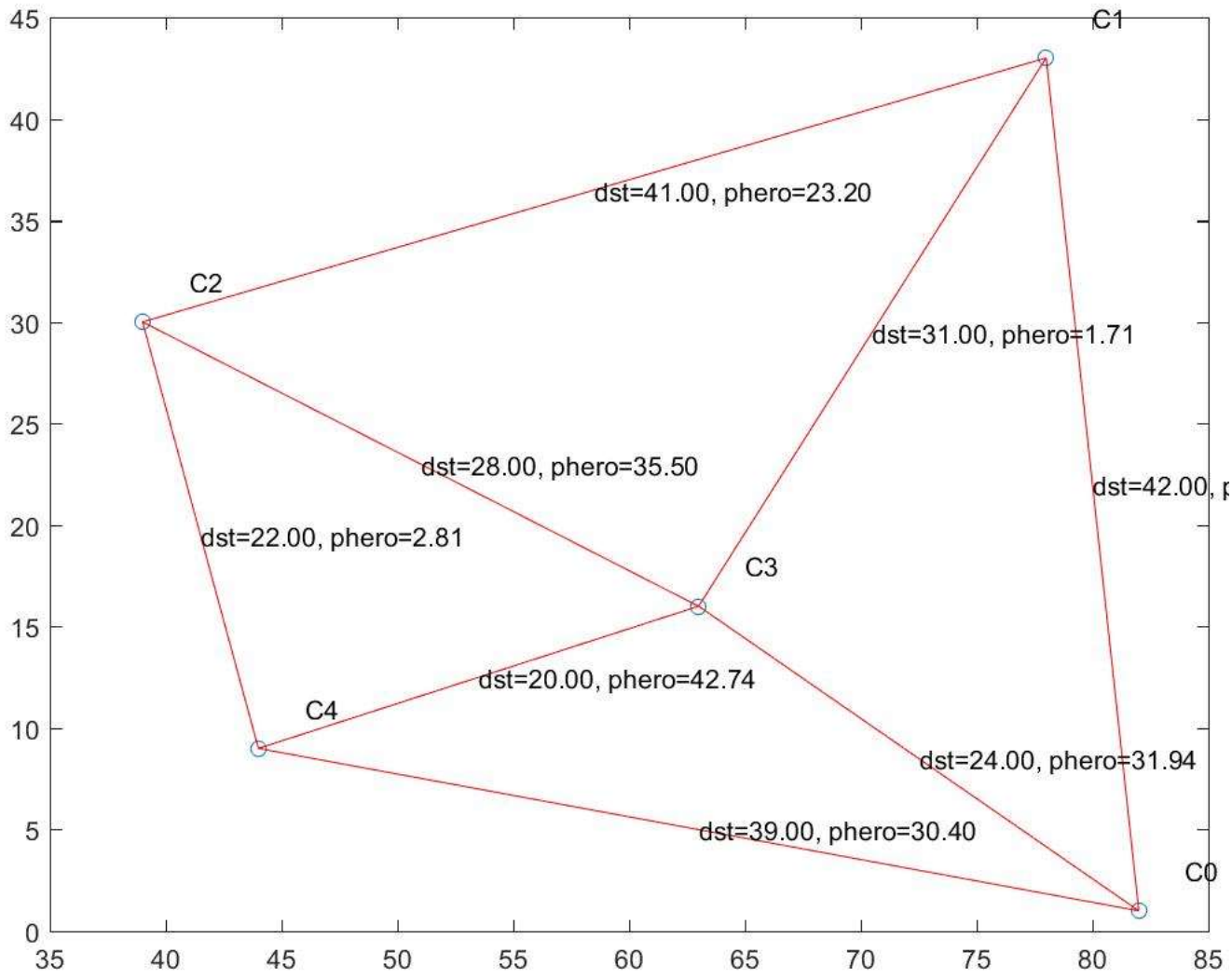
Question 28

At a given point of time and given an ant, the ant found 3 possible routes at its journey. The pheromone amounts on each route are :
6.000000 9.000000 4.000000
If the length of each route which is inversely proportional to the route desirability is known to the ant and lengths are :
46.000000 21.000000 43.000000
Calculate the probability of selecting each route by that given ant
Assume Alpha=0.3 and beta= 0.8

Answer
eta=1/d
eta1=0.021739
eta2=0.047619
eta3=0.023256
P-1=0.246956
P-2=0.522250
P-3=0.230794

Question 29

In a TSP problem with 5 cities, cities are connected as shown in the figure:



the following table shows the distances between different cities

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	42.00	52.00	24.00	39.00
C1	42.00	0.00	41.00	31.00	48.00
C2	52.00	41.00	0.00	28.00	22.00
C3	24.00	31.00	28.00	0.00	20.00
C4	39.00	48.00	22.00	20.00	0.00

[Distance of 0 means distance is not applicable.
]The following table shows the pheromone in units between different cities

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	42.17	0.00	31.94	30.40
C1	42.17	0.00	23.20	1.71	0.00
C2	0.00	23.20	0.00	35.50	2.81
C3	31.94	1.71	35.50	0.00	42.74
C4	30.40	0.00	2.81	42.74	0.00

- Assume that an ant has followed the following route:[1,3,2,4,0,] and back to source

  a. Calculate the total cost of the above route.
  b. Calculate the ant's switching probabilities for the first 2 steps in the above route assuming pheromone exponent parameter α=0.56 and heuristic exponent parameter β=0.30.
  c. Calculate the updated pheromone amounts after applying the ACO evaporation step assuming ρ=0.37.
  d. Calculate the updated pheromone amounts after applying the ACO depositing step assuming Q=13.96.

Answer

a. The cost of the aforementioned route:162.00
b. At node 1 the ant has 3 choices:From C1 to C2 the heuristic value is 0.02 and its pheromone value is 23.20 hence P=0.38
From C1 to C3 the heuristic value is 0.03 and its pheromone value is 1.71 hence P=0.10
From C1 to C0 the heuristic value is 0.02 and its pheromone value is 42.17 hence P=0.53
At node 3 the ant has 3 choices:From C3 to C4 the heuristic value is 0.05 and its pheromone value is 42.74 hence P=0.38
From C3 to C0 the heuristic value is 0.04 and its pheromone value is 31.94 hence P=0.31
From C3 to C2 the heuristic value is 0.04 and its pheromone value is 35.50 hence P=0.31
c. The pheromone matrix will evaporate according to the rule:pheromone=(1-ρ)pheromone

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	26.57	0.00	20.12	19.15
C1	26.57	0.00	14.62	1.08	0.00
C2	0.00	14.62	0.00	22.36	1.77
C3	20.12	1.08	22.36	0.00	26.93
C4	19.15	0.00	1.77	26.93	0.00

The route links pheromone will be enhanced by Δ=Q/L (where L is the path cost)
Δ=0.09
The updated Pheromone matrix:

	C0	**C1**	**C2**	**C3**	**C4**
C0	0.00	26.65	0.00	20.12	19.15
C1	26.57	0.00	14.62	1.16	0.00
C2	0.00	14.62	0.00	22.36	1.86
C3	20.12	1.08	22.45	0.00	26.93
C4	19.24	0.00	1.77	26.93	0.00

Question 30

Having the following rouing table at node 5

	N34	**N43**	**N71**	**N89**	**N86**
N13	0.20	0.20	0.30	0.20	0.36
N12	0.21	0.11	0.51	0.27	0.16
N84	0.31	0.52	0.05	0.42	0.29
N61	0.29	0.16	0.14	0.10	0.19

Having started at node 34 and reaching node 5 via node 84.Assuming it has been in the network for 3.857285 time units, what effect will it have on the routing table on node 5
assume a and b equals 0.030000 and 0.030000 in order for ABC model

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δr=a/T+b
δr=0.037777
r3_1=(r3_1+δr)/(1+δr)
=0.332269
The remaining cells in the source column will be updated by rks/(1+δr)
The updated table will be:

	N34	**N43**	**N71**	**N89**	**N86**
N13	0.19	0.20	0.30	0.20	0.36
N12	0.20	0.11	0.51	0.27	0.16
N84	0.33	0.52	0.05	0.42	0.29
N61	0.28	0.16	0.14	0.10	0.19