

Question 1

Pick an online or physical network (choose one with ~1k-10k nodes). See Datasets (Module 1). Submit code or link of code.

Provide a good visualization of your network.

Find the characteristics of your network (centralities).

Answer additional questions:

- How does your network cluster?
- What structural properties can you detect?
- How many of these relations would you consider “strong”?

Some ideas: #Nodes, #Edges, Diameter, Isolated nodes, Density, Max degree, Min degree, Average degree, Size of largest components, Number of connected components, degree of assortativity etc.

Dataset : roadNet-CA.txt

Link : [roadNet-CA.txt](#)

Dataset consists of network of roads in California. It is an undirected graph (one way roads are avoided).

Nodes represent the Intersections and endpoints of roads.

Edges represent road intersections.

Only first N lines in the txt file of dataset are used for this activity

Dataset statistics	
Nodes	1965206
Edges	2766607
Nodes in largest WCC	1957027 (0.996)
Edges in largest WCC	2760388 (0.998)
Nodes in largest SCC	1957027 (0.996)
Edges in largest SCC	2760388 (0.998)
Average clustering coefficient	0.0464
Number of triangles	120676
Fraction of closed triangles	0.02097
Diameter (longest shortest path)	849
90-percentile effective diameter	5e+02

```
In [1]: import networkx as nx  
import matplotlib.pyplot as plt  
import pandas as pd
```

```
In [2]: # Importing data (Only first N lines in the txt file of dataset are used  
  
N = 3000  
  
# Read the space-separated text file  
with open('roadNet-CA.txt', 'r') as file:  
    lines = file.readlines()  
  
lines = lines[:N]
```

```
In [3]: # printing the last line mentioned in the txt file of dataset  
lines[-1]
```

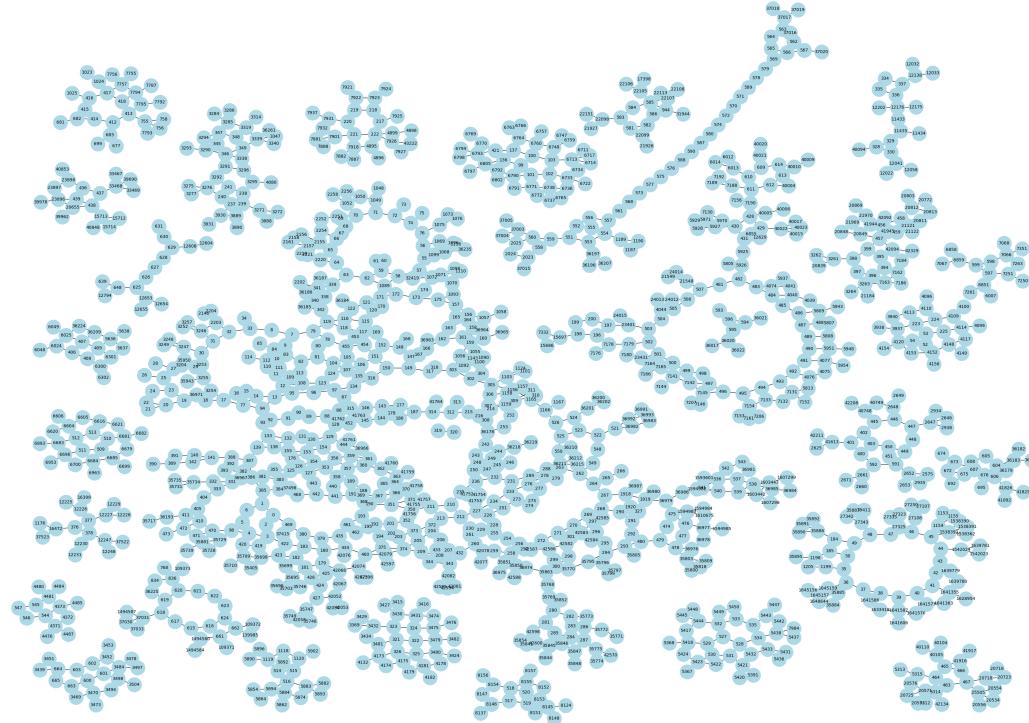
```
Out[3]: '12608\t12604\n'
```

Import Data

```
In [4]: # Initialize a graph  
####  
There are errors while parsing the txt file due to newlines , tabs , white spaces.  
In such cases a ValueError is raised.  
The output of this cell returns the line in txt file that raises the ValueError  
####  
  
G = nx.Graph()  
  
try :  
    for idx, line in enumerate(lines):  
  
        # Split space-separated values  
        node1, node2 = map(int, line.rstrip().split("\t"))  
  
        G.add_edge(node1, node2)  
  
except ValueError :  
    print("Exception occurred at : ",node1 , node2)
```

```
In [5]: plt.figure(figsize=(40,28))
```

```
nx.draw(G, pos = nx.nx_pydots.layout(G), node_size=1200, node_color='red', edge_color='blue', width=2)  
plt.show()
```

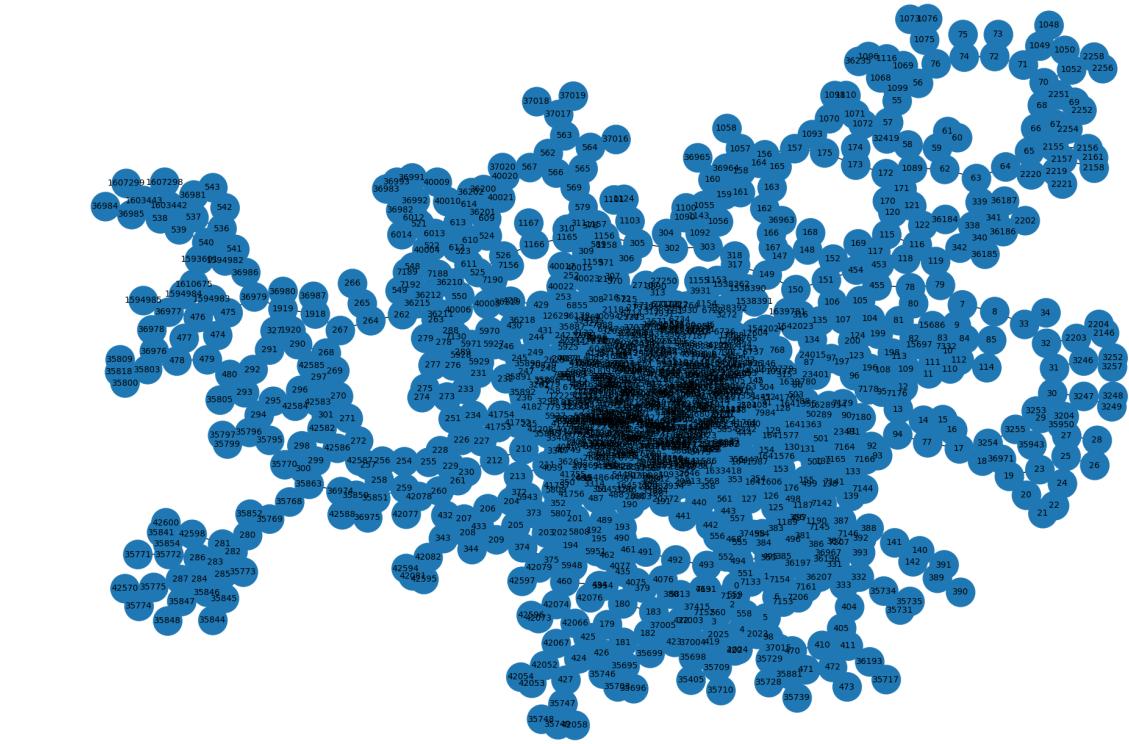


```
In [6]: #Kamada Kawai
plt.figure(figsize=(20,14))
nx.draw_kamada_kawai(G , with_labels=True,node_size=1200,linewidths=0.25,
```



```
# nx.draw(G, pos = nx.nx_pydot.graphviz_layout(G), \
#         node_size=1200, node_color='lightblue', linewidths=0.25, \
#         font_size=10, with_labels=True)
plt.title("Kamada Kawai")
```

```
Out[6]: Text(0.5, 1.0, 'Kamada Kawai')
```



Graph Statistics

```
In [7]: # Now G contains the filtered graph. You can print or visualize it.  
print("Nodes:", G.nodes())  
print("Edges:", G.edges())  
  
print(f"Total number of nodes : {len(G.nodes())}")  
print(f"Total number of edges : {len(G.edges())}")
```

Nodes: [0, 1, 2, 469, 6, 385, 3, 380, 37415, 5, 384, 386, 4, 419, 422, 9, 8, 420, 35698, 183, 423, 470, 35729, 35709, 7, 8, 9, 79, 33, 10, 84, 78, 119, 32, 34, 11, 110, 83, 85, 12, 111, 112, 13, 95, 108, 14, 94, 109, 11, 3, 123, 96, 15, 16, 77, 93, 17, 18, 3254, 19, 3255, 36971, 20, 23, 21, 2, 2, 24, 25, 26, 27, 28, 29, 30, 31, 3247, 3253, 35943, 3246, 3248, 3249, 3, 204, 35950, 2203, 3252, 3257, 2146, 2204, 35, 36, 50, 1199, 37, 35885, 16, 45159, 49, 185, 1198, 1205, 38, 1641586, 35884, 1645157, 1645156, 164864, 4, 39, 1633418, 40, 1641587, 41, 1641577, 1641576, 1641606, 42, 1641355, 1641363, 43, 1639779, 1628954, 1639780, 44, 45, 1542024, 46, 1154, 153839, 2, 1542023, 1639781, 47, 27108, 27325, 1153, 1155, 1538362, 1538390, 1538, 391, 48, 27107, 27250, 27323, 27335, 27343, 184, 27342, 35887, 39411, 358, 86, 52, 53, 54, 4152, 223, 225, 4120, 4148, 4153, 4156, 224, 3937, 4113, 4114, 4154, 55, 56, 57, 1068, 1099, 76, 1069, 58, 1071, 1072, 1096, 1116, 36235, 74, 1075, 59, 1089, 32419, 1070, 1098, 1110, 60, 61, 62, 171, 172, 63, 64, 339, 65, 2220, 338, 341, 36187, 66, 2155, 2157, 2219, 2221, 67, 6, 8, 2254, 2156, 2158, 2161, 69, 70, 2251, 2252, 71, 1052, 72, 1049, 1050, 2256, 2258, 73, 1048, 75, 1073, 1076, 80, 455, 81, 105, 454, 116, 118, 34, 2, 82, 104, 107, 124, 114, 86, 87, 88, 128, 315, 97, 134, 89, 146, 129, 4, 52, 135, 316, 90, 91, 92, 133, 132, 139, 410, 471, 35881, 35728, 99, 100, 101, 136, 6790, 103, 137, 6760, 102, 6771, 421, 6792, 6805, 6791, 6802, 6, 713, 6748, 6764, 6757, 6733, 6738, 6772, 6722, 6734, 6736, 6737, 6765, 67, 11, 6714, 6717, 6747, 6759, 106, 151, 150, 152, 115, 117, 120, 169, 122,

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Total number of nodes : 1410  
Total number of edges : 1763
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In [8]: nx.is_connected(G) # Check whether the graph is fully connected
```

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Out[8]: False
```

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In [ ]:
```

```
In [9]: # Computes subgraphs and stores them in a list  
S = [G.subgraph(c).copy() for c in nx.connected_components(G)]
```

```
In [10]: # Print subgraphs and its statistics  
for graph_idx, graph in enumerate(S) :  
    print("-"*20,f"Graph {graph_idx}", "-"*20)  
  
    plt.figure(figsize=(20,14))  
    nx.draw(S[graph_idx], pos = nx.nx_pydots.graphviz_layout(S[graph_idx]))  
    plt.show()  
  
    print("-"*10,"Graph Stats ", "*10)  
  
    num_edges = graph.number_of_edges()  
    num_nodes = graph.number_of_nodes()  
  
    print(f"Nodes : {num_nodes} Edges : {num_nodes}")  
  
    print(f"Diameter : {nx.diameter(graph)}") # Diameter  
  
    print(f"Periphery : {nx.periphery(graph)}") # Periphery  
  
    degrees = [graph.degree(n) for n in graph.nodes()]  
    plt.hist(degrees)  
  
    # Density  
    density = nx.density(graph)  
    print(f"Density of the graph: {density}")  
  
    # Max and Min degree  
    degrees = dict(graph.degree())  
    max_degree = max(degrees.values())  
    min_degree = min(degrees.values())  
  
    # Average degree
```

```

avg_degree = (2 * num_edges) / num_nodes
print(f"Average degree: {avg_degree}")

# Number of connected components

connected_components = list(nx.connected_components(graph))
largest_component_size = max(len(c) for c in connected_components) #
print(f"Size of the largest connected component: {largest_component_s}

# Degree assortativity
assortativity = nx.degree_assortativity_coefficient(graph)
print(f"Degree assortativity coefficient: {assortativity}")


# Degree Centrality
deg_centrality=nx.degree_centrality(graph)
res = {key : round(deg_centrality[key], 3) for key in deg_centrality}
df=pd.DataFrame(res.items(), columns=["Node", "Degree Centrality"])
print(df.sort_values('Degree Centrality', ascending=False))

# Closeness Centrality
Closeness_centrality=nx.closeness_centrality(graph)
res = {key : round(Closeness_centrality[key], 3) for key in Closeness_centrality}
df=pd.DataFrame(res.items(), columns=["Node", "Closeness Centrality"])
print(df.sort_values('Closeness Centrality', ascending=False))

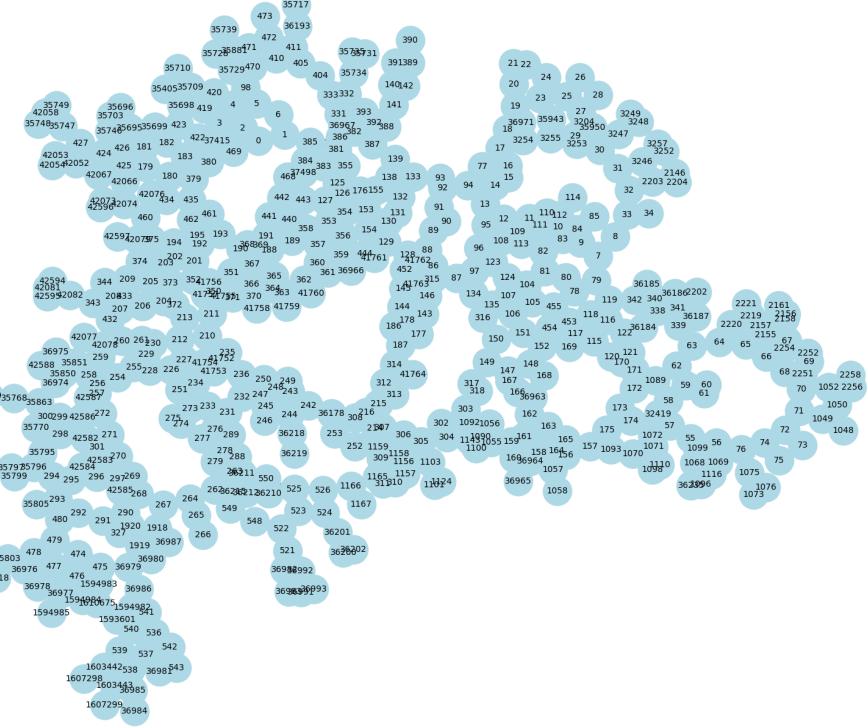
# Between Centrality
Betweenness_centrality=nx.betweenness_centrality(graph)
res = {key : round(Betweenness_centrality[key], 3) for key in Betweenness_centrality}
df=pd.DataFrame(res.items(), columns=["Node", "Betweenness Centrality"])
print(df.sort_values('Betweenness Centrality', ascending=False))

# Katz Centrality
Katz_centrality=nx.katz_centrality(graph,alpha=0.05, beta=1.0, max_iter=100)
res = {key : round(Katz_centrality[key], 3) for key in Katz_centrality}
df=pd.DataFrame(res.items(), columns=["Node", "Katz Centrality"])
print(df.sort_values('Katz Centrality', ascending=False))

plt.show()
print("-"*50)

```

----- Graph 0 -----



----- Graph Stats -----

Nodes : 591 Edges : 591

Diameter : 45

Periphery : [2256, 2258, 35774, 35848, 42570]

Density of the graph: 0.004468152226906421

Average degree: 2.6362098138747885

Size of the largest connected component: 591

Degree assortativity coefficient: -0.07240299819279103

	Node	Degree	Centrality
475	1068	0.008	
105	125	0.008	
131	151	0.007	
159	179	0.007	
362	470	0.007	
..
80	36963	0.002	
448	35797	0.002	
449	35799	0.002	
450	35800	0.002	
590	1593601	0.002	

[591 rows x 2 columns]

	Node	Closeness	Centrality
109	129	0.077	
168	190	0.076	
169	191	0.076	
312	371	0.076	
183	210	0.076	
..
190	2256	0.040	
191	2258	0.040	
569	1607299	0.040	
579	36984	0.039	

466 1048 0.039

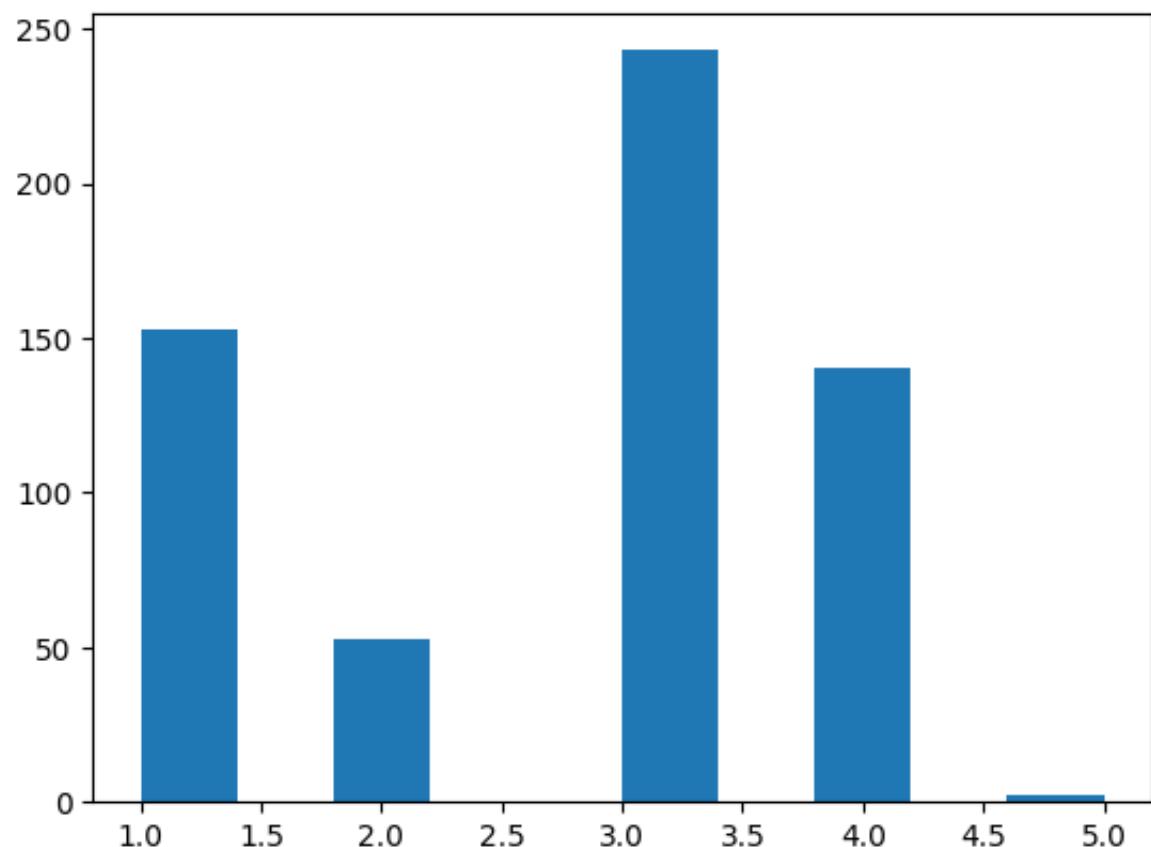
[591 rows x 2 columns]

	Node	Betweenness Centrality
264	303	0.222
266	305	0.211
263	302	0.203
185	212	0.189
224	263	0.182
..
464	35854	0.000
236	275	0.000
466	1048	0.000
235	274	0.000
590	1593601	0.000

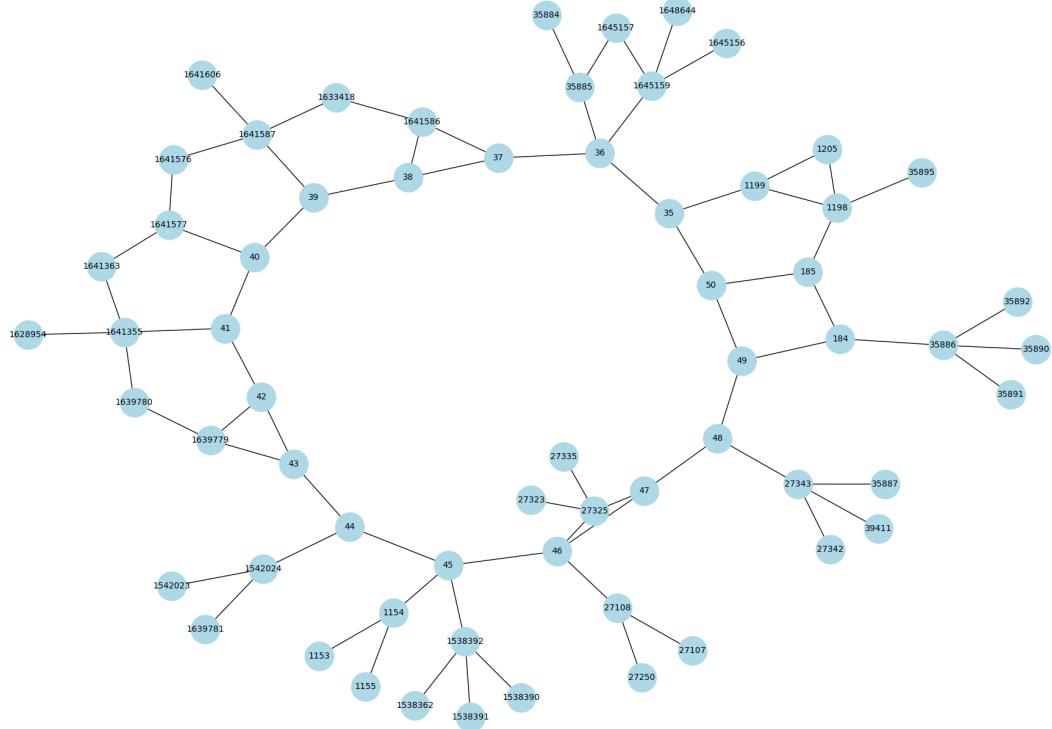
[591 rows x 2 columns]

	Node	Katz Centrality
105	125	0.046
475	1068	0.046
294	353	0.044
108	128	0.044
109	129	0.044
..
455	35841	0.038
456	35844	0.038
65	85	0.038
460	35848	0.038
590	1593601	0.038

[591 rows x 2 columns]



----- Graph 1 -----



----- Graph Stats -----

Nodes : 63 Edges : 63

Diameter : 13

Periphery : [1628954, 35890, 35891, 35892]

Density of the graph: 0.03789042498719918

Average degree: 2.3492063492063493

Size of the largest connected component: 63

Degree assortativity coefficient: -0.47263681592039875

	Node	Degree Centrality
22	1198	0.065
28	35886	0.065
43	27343	0.065
60	1641587	0.065
48	45	0.065
..
39	1538362	0.016
40	27335	0.016
41	35887	0.016
42	27342	0.016
62	27250	0.016

[63 rows x 2 columns]

	Node	Closeness Centrality
24	48	0.207
30	46	0.206
25	49	0.206
27	47	0.206
48	45	0.202
..
36	35892	0.134
35	35891	0.134
34	35890	0.134
10	1628954	0.133

4 1641606 0.133

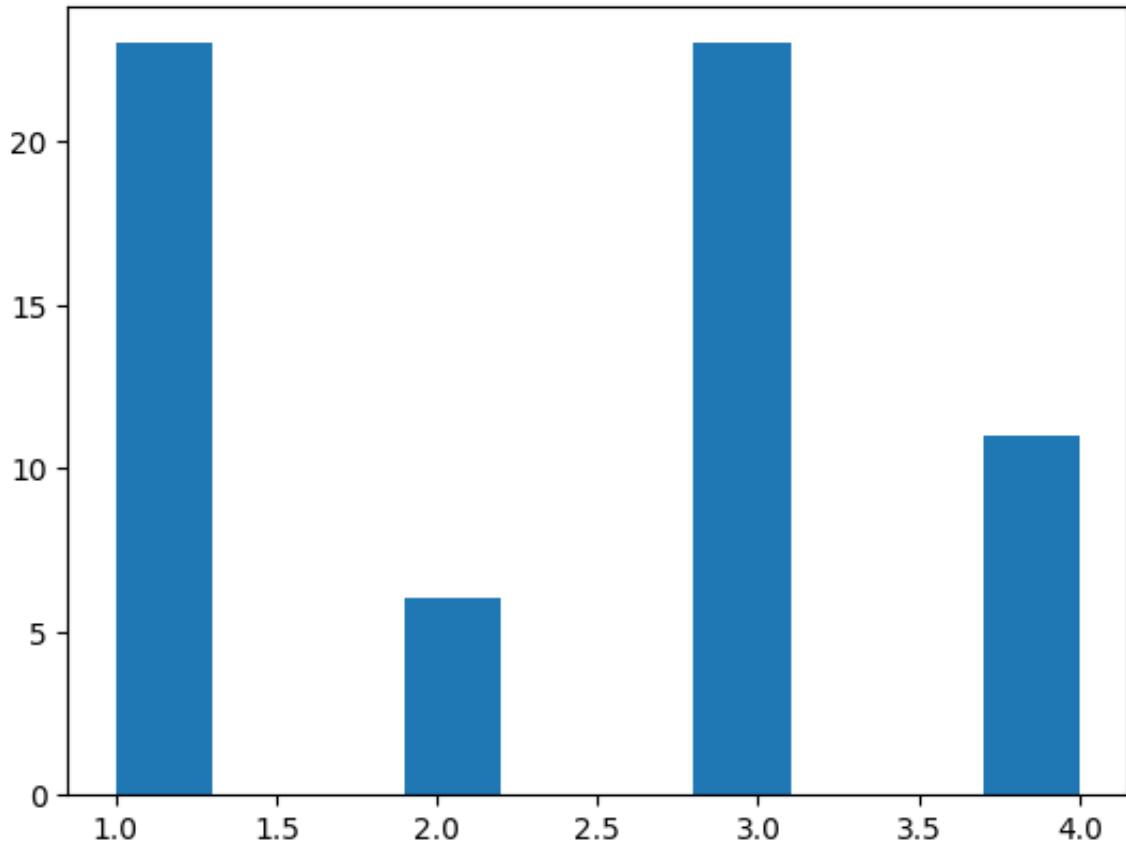
[63 rows x 2 columns]

	Node	Betweenness Centrality
48	45	0.380
24	48	0.368
30	46	0.348
25	49	0.334
12	36	0.321
..
38	27323	0.000
39	1538362	0.000
40	27335	0.000
41	35887	0.000
62	27250	0.000

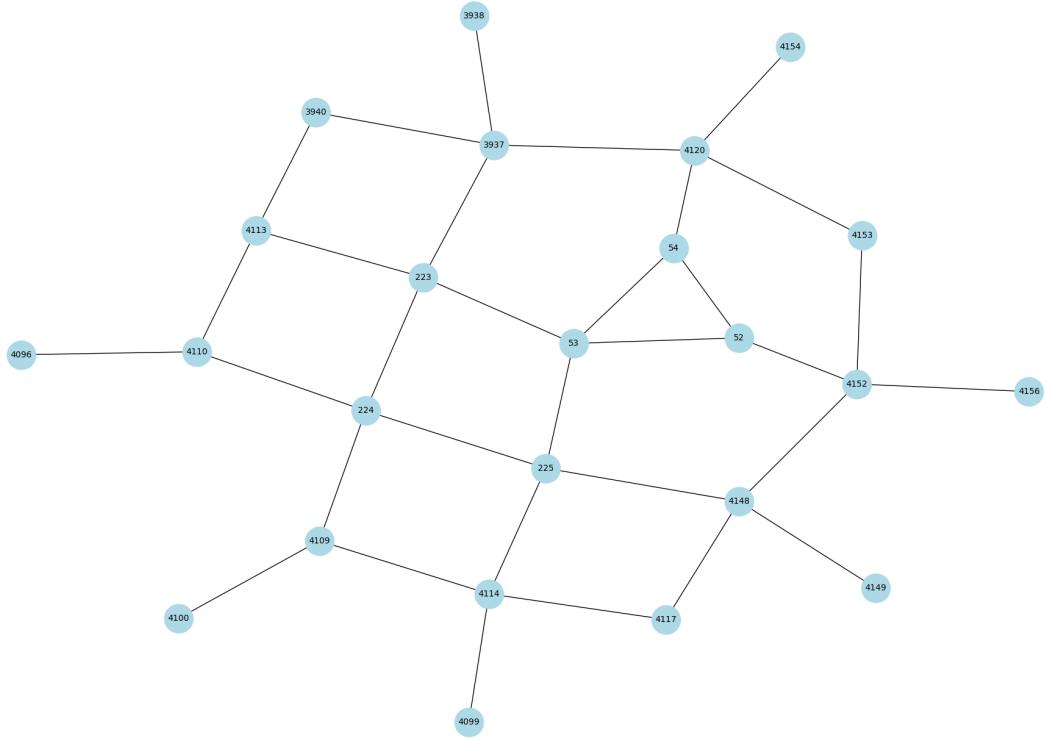
[63 rows x 2 columns]

	Node	Katz Centrality
12	36	0.137
48	45	0.137
30	46	0.137
22	1198	0.136
37	27325	0.136
..
39	1538362	0.117
40	27335	0.117
41	35887	0.117
42	27342	0.117
62	27250	0.117

[63 rows x 2 columns]



----- Graph 2 -----



----- Graph Stats -----

Nodes : 24 Edges : 24

Diameter : 6

Periphery : [4096, 4099, 4100, 4117, 4149, 4154, 4153, 4156, 3938, 3940]

Density of the graph: 0.11594202898550725

Average degree: 2.6666666666666665

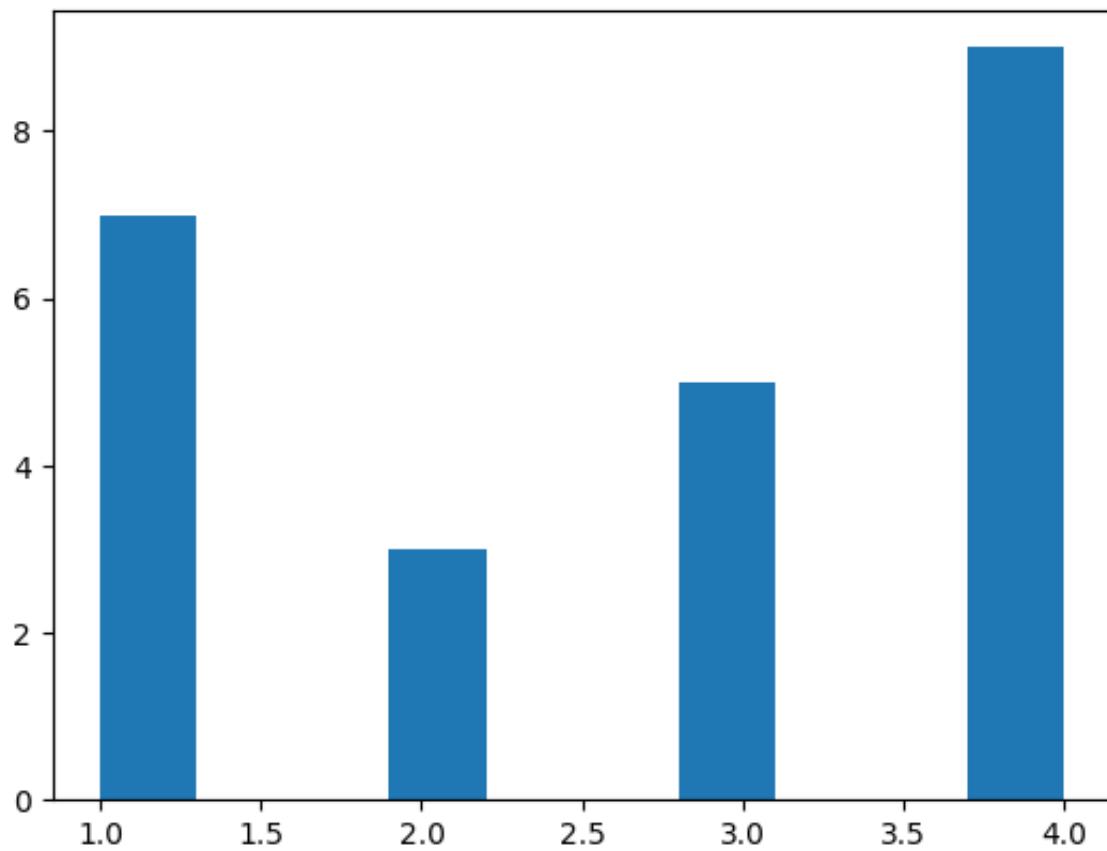
Size of the largest connected component: 24

Degree assortativity coefficient: -0.24242424242424243

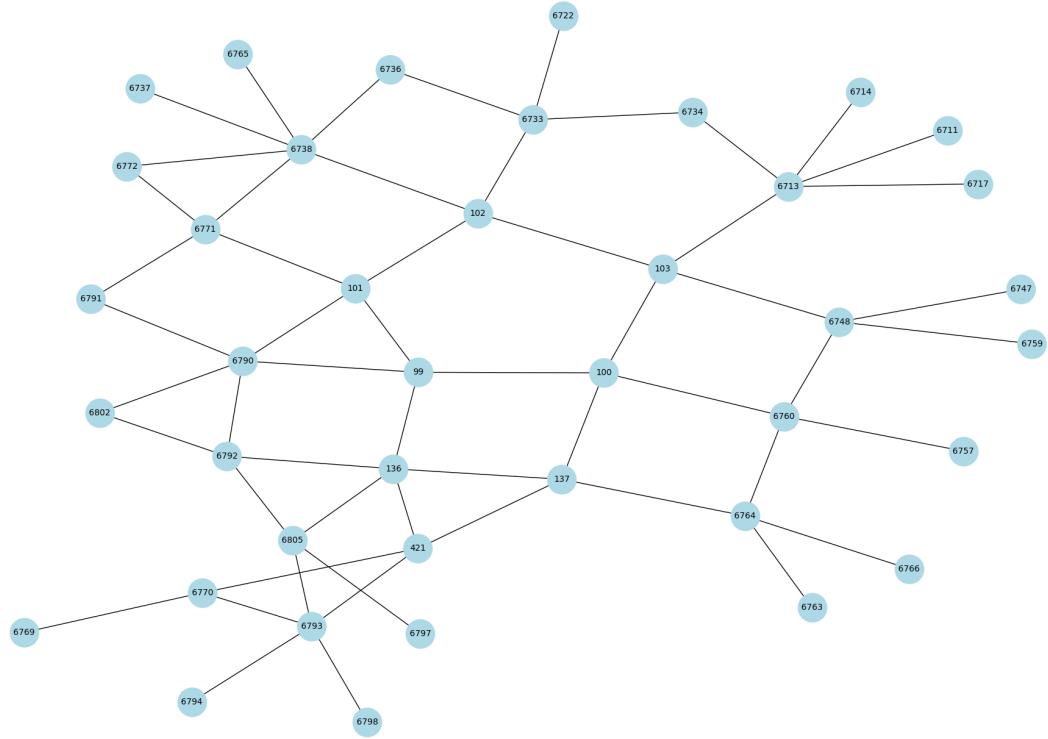
Node	Degree	Centrality
12	4148	0.174
21	3937	0.174
6	4114	0.174
20	225	0.174
8	4120	0.174
10	53	0.174
19	224	0.174
13	4152	0.174
18	223	0.174
3	4109	0.130
4	4110	0.130
5	4113	0.130
9	52	0.130
11	54	0.130
16	4153	0.087
23	3940	0.087
7	4117	0.087
15	4154	0.043
17	4156	0.043
14	4149	0.043
1	4099	0.043
2	4100	0.043
22	3938	0.043
0	4096	0.043

	Node	Closeness Centrality
20	225	0.418
10	53	0.411
19	224	0.404
18	223	0.404
12	4148	0.359
13	4152	0.354
21	3937	0.348
8	4120	0.348
9	52	0.348
11	54	0.348
6	4114	0.333
3	4109	0.324
4	4110	0.315
5	4113	0.315
16	4153	0.311
7	4117	0.295
23	3940	0.280
14	4149	0.267
17	4156	0.264
15	4154	0.261
22	3938	0.261
1	4099	0.253
2	4100	0.247
0	4096	0.242
	Node	Betweenness Centrality
20	225	0.276
19	224	0.272
18	223	0.241
12	4148	0.215
21	3937	0.205
13	4152	0.176
10	53	0.173
8	4120	0.172
6	4114	0.156
3	4109	0.121
4	4110	0.110
16	4153	0.071
5	4113	0.071
11	54	0.047
9	52	0.039
7	4117	0.032
23	3940	0.022
17	4156	0.000
15	4154	0.000
14	4149	0.000
1	4099	0.000
2	4100	0.000
22	3938	0.000
0	4096	0.000
	Node	Katz Centrality
20	225	0.219
18	223	0.219
10	53	0.218
19	224	0.218
12	4148	0.217
21	3937	0.217

6	4114	0.216
8	4120	0.216
13	4152	0.216
9	52	0.208
11	54	0.208
3	4109	0.207
5	4113	0.207
4	4110	0.206
16	4153	0.197
23	3940	0.197
7	4117	0.197
15	4154	0.187
17	4156	0.187
14	4149	0.187
1	4099	0.187
22	3938	0.187
2	4100	0.186
0	4096	0.186



----- Graph 3 -----



----- Graph Stats -----

Nodes : 40 Edges : 40

Diameter : 8

Periphery : [6794, 6798, 6722, 6736, 6737, 6765, 6769]

Density of the graph: 0.07051282051282051

Average degree: 2.75

Size of the largest connected component: 40

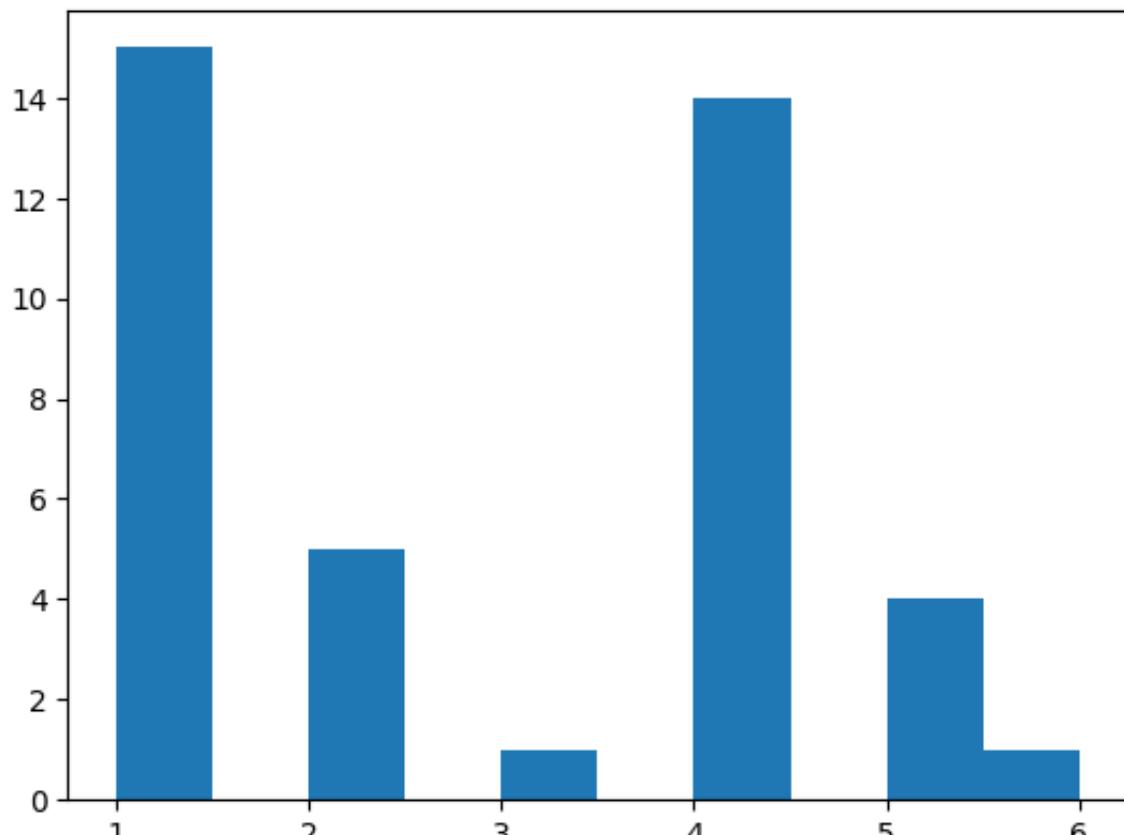
Degree assortativity coefficient: -0.42708873897249455

	Node	Degree	Centrality
21	6738	0	0.154
0	6790	1	0.128
2	136	1	0.128
5	6793	1	0.128
13	6713	1	0.128
28	103	1	0.103
24	99	1	0.103
17	6733	1	0.103
25	100	1	0.103
26	101	1	0.103
27	102	1	0.103
10	6805	1	0.103
11	421	1	0.103
29	6760	1	0.103
33	6764	1	0.103
38	6771	1	0.103
4	6792	1	0.103
3	137	1	0.103
23	6748	1	0.103
37	6770	1	0.077
39	6772	1	0.051
1	6791	1	0.051
19	6736	1	0.051
18	6734	1	0.051

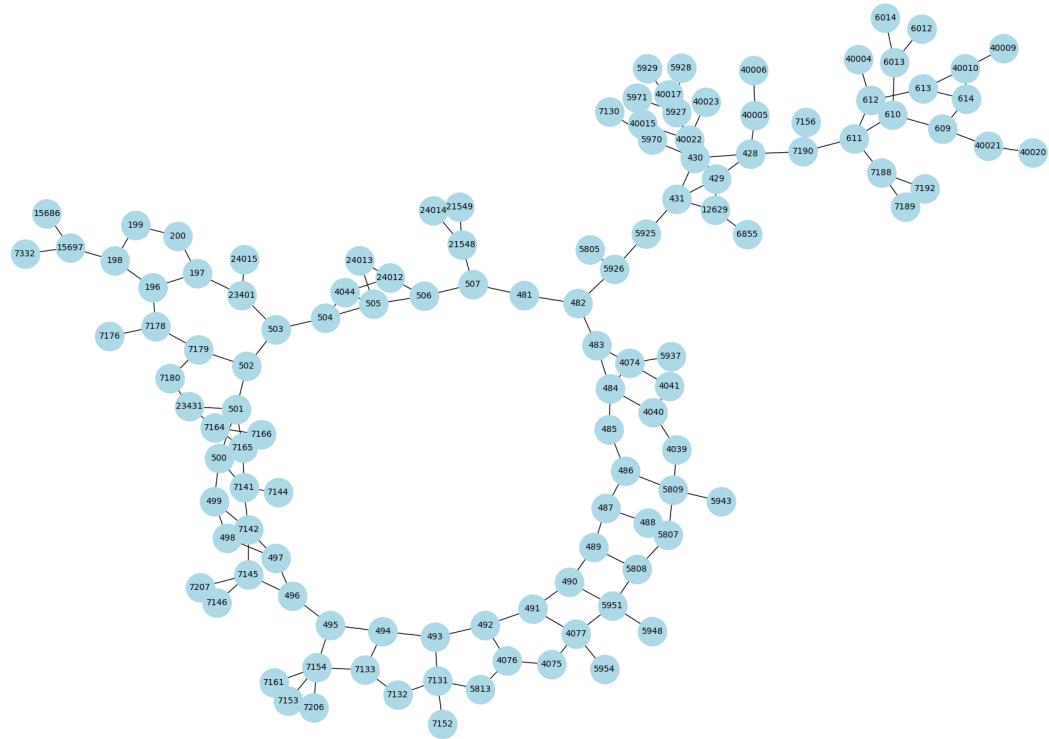
9	6802	0.051
32	6763	0.026
6	6794	0.026
7	6797	0.026
36	6769	0.026
35	6766	0.026
34	6765	0.026
8	6798	0.026
30	6757	0.026
31	6759	0.026
22	6747	0.026
12	6711	0.026
14	6714	0.026
15	6717	0.026
16	6722	0.026
20	6737	0.026
Node Closeness Centrality		
25	100	0.358
28	103	0.345
24	99	0.342
3	137	0.325
26	101	0.325
27	102	0.325
2	136	0.312
0	6790	0.300
29	6760	0.293
23	6748	0.285
11	421	0.285
13	6713	0.279
4	6792	0.277
33	6764	0.271
38	6771	0.267
21	6738	0.267
17	6733	0.264
10	6805	0.262
9	6802	0.253
1	6791	0.250
5	6793	0.242
18	6734	0.242
37	6770	0.232
39	6772	0.232
30	6757	0.228
19	6736	0.224
22	6747	0.223
31	6759	0.223
15	6717	0.219
14	6714	0.219
12	6711	0.219
32	6763	0.214
35	6766	0.214
34	6765	0.212
20	6737	0.212
16	6722	0.210
7	6797	0.209
8	6798	0.196
6	6794	0.196
36	6769	0.189

	Node	Betweenness Centrality
28	103	0.349
25	100	0.275
27	102	0.261
3	137	0.225
13	6713	0.176
26	101	0.172
24	99	0.168
11	421	0.166
2	136	0.161
21	6738	0.161
29	6760	0.144
23	6748	0.138
33	6764	0.126
0	6790	0.117
5	6793	0.112
10	6805	0.101
17	6733	0.090
38	6771	0.076
4	6792	0.071
37	6770	0.051
1	6791	0.017
18	6734	0.016
19	6736	0.010
34	6765	0.000
32	6763	0.000
31	6759	0.000
35	6766	0.000
30	6757	0.000
36	6769	0.000
20	6737	0.000
22	6747	0.000
16	6722	0.000
15	6717	0.000
14	6714	0.000
12	6711	0.000
9	6802	0.000
8	6798	0.000
7	6797	0.000
6	6794	0.000
39	6772	0.000
	Node	Katz Centrality
21	6738	0.181
2	136	0.177
0	6790	0.175
5	6793	0.174
13	6713	0.173
28	103	0.169
3	137	0.169
24	99	0.169
25	100	0.169
26	101	0.169
27	102	0.169
11	421	0.169
10	6805	0.168
38	6771	0.168
4	6792	0.168

29	6760	0.167
33	6764	0.166
17	6733	0.166
23	6748	0.166
37	6770	0.159
39	6772	0.152
1	6791	0.152
9	6802	0.152
19	6736	0.152
18	6734	0.152
6	6794	0.144
34	6765	0.144
8	6798	0.144
20	6737	0.144
12	6711	0.144
14	6714	0.144
15	6717	0.144
22	6747	0.143
31	6759	0.143
32	6763	0.143
35	6766	0.143
36	6769	0.143
7	6797	0.143
16	6722	0.143
30	6757	0.143



Graph 4



----- Graph Stats -----

Nodes : 121 Edges : 121

Diameter : 25

Periphery : [7206, 40009, 40020, 7153, 7161]

Density of the graph: 0.020523415977961434

Average degree: 2.4628099173553717

Size of the largest connected component: 121

Degree assortativity coefficient: -0.20686639974227827

Node	Degree	Centrality
119	501	0.042
32	7154	0.042
26	611	0.033
102	4077	0.033
47	7165	0.033
..
86	7130	0.008
54	5937	0.008
23	40023	0.008
97	488	0.008
0	7176	0.008

[121 rows x 2 columns]

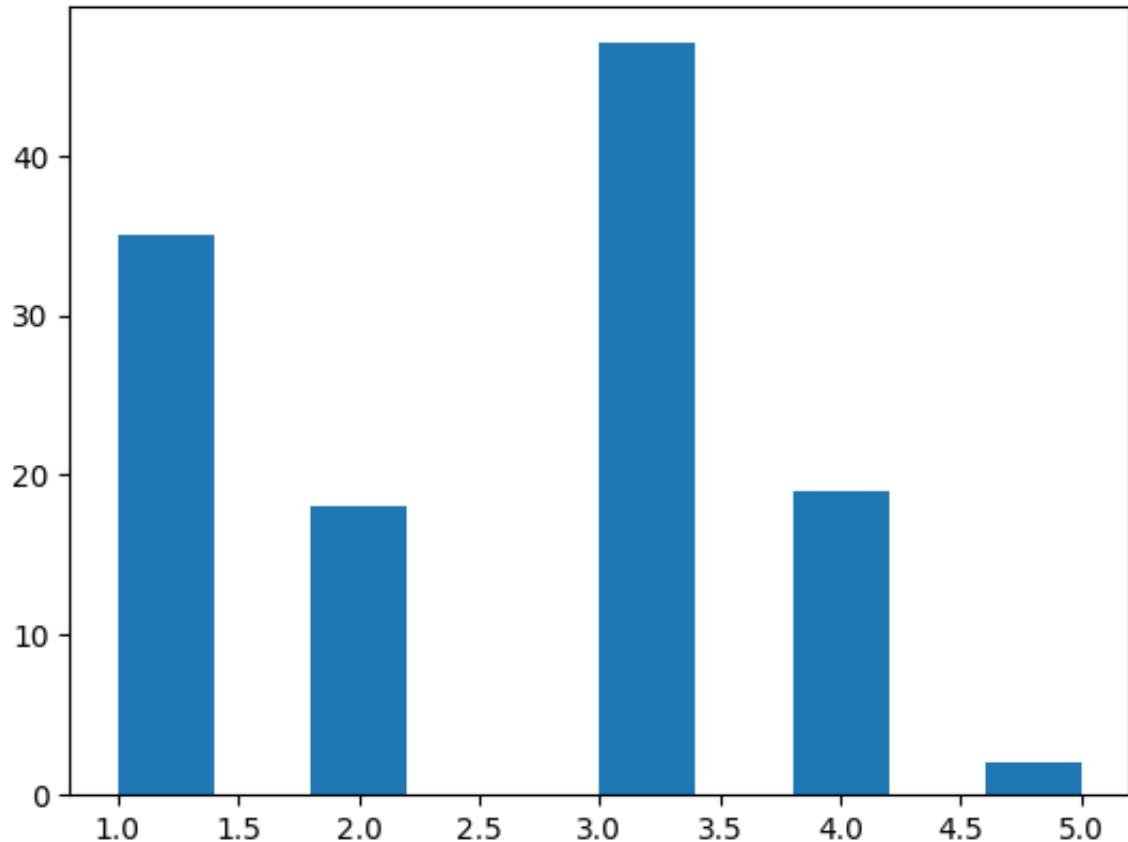
Node	Closeness	Centrality
91	482	0.131
90	481	0.126
50	5926	0.125
92	483	0.125
116	507	0.123
..
65	6012	0.071
59	15686	0.071
67	6014	0.071
16	40009	0.067

20 40020 0.067

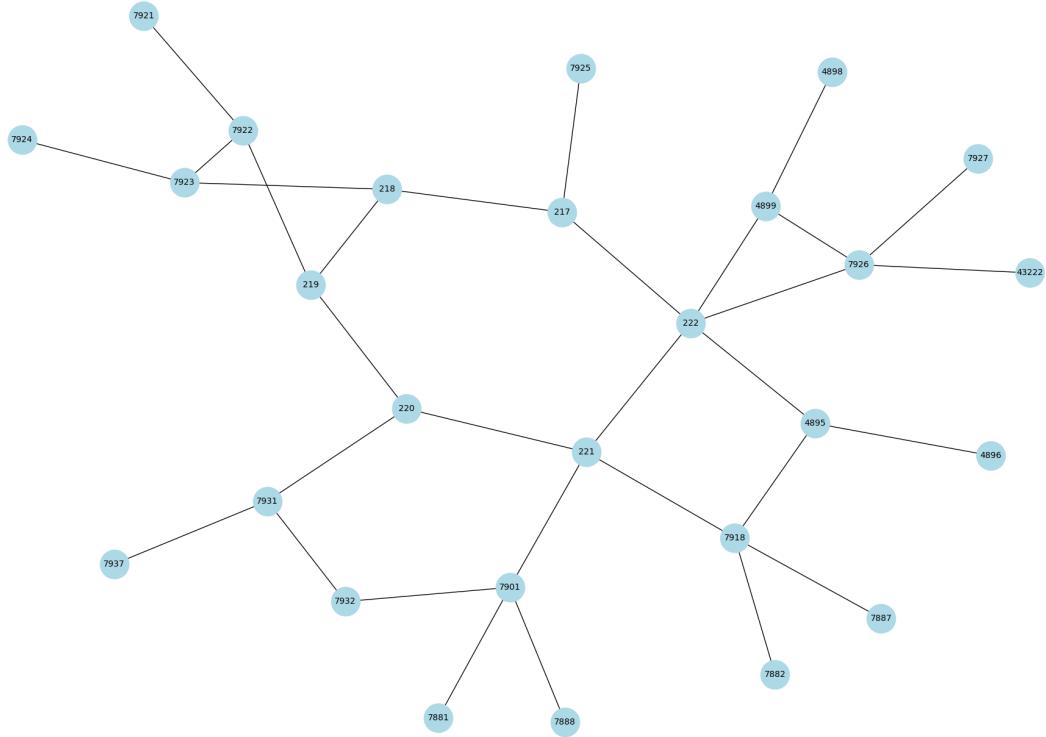
[121 rows x 2 columns]
Node Betweenness Centrality
91 482 0.537
50 5926 0.448
49 5925 0.430
73 431 0.428
116 507 0.340
..
86 7130 0.000
33 7332 0.000
31 7153 0.000
30 7146 0.000
0 7176 0.000

[121 rows x 2 columns]
Node Katz Centrality
119 501 0.103
32 7154 0.101
71 429 0.099
72 430 0.099
47 7165 0.099
..
65 6012 0.084
34 5805 0.084
33 7332 0.084
97 488 0.084
0 7176 0.084

[121 rows x 2 columns]



----- Graph 5 -----



----- Graph Stats -----

Nodes : 27 Edges : 27

Diameter : 7

Periphery : [4896, 4898, 7881, 7882, 7887, 7888, 43222, 7921, 7924, 7927]

Density of the graph: 0.08831908831908832

Average degree: 2.2962962962962963

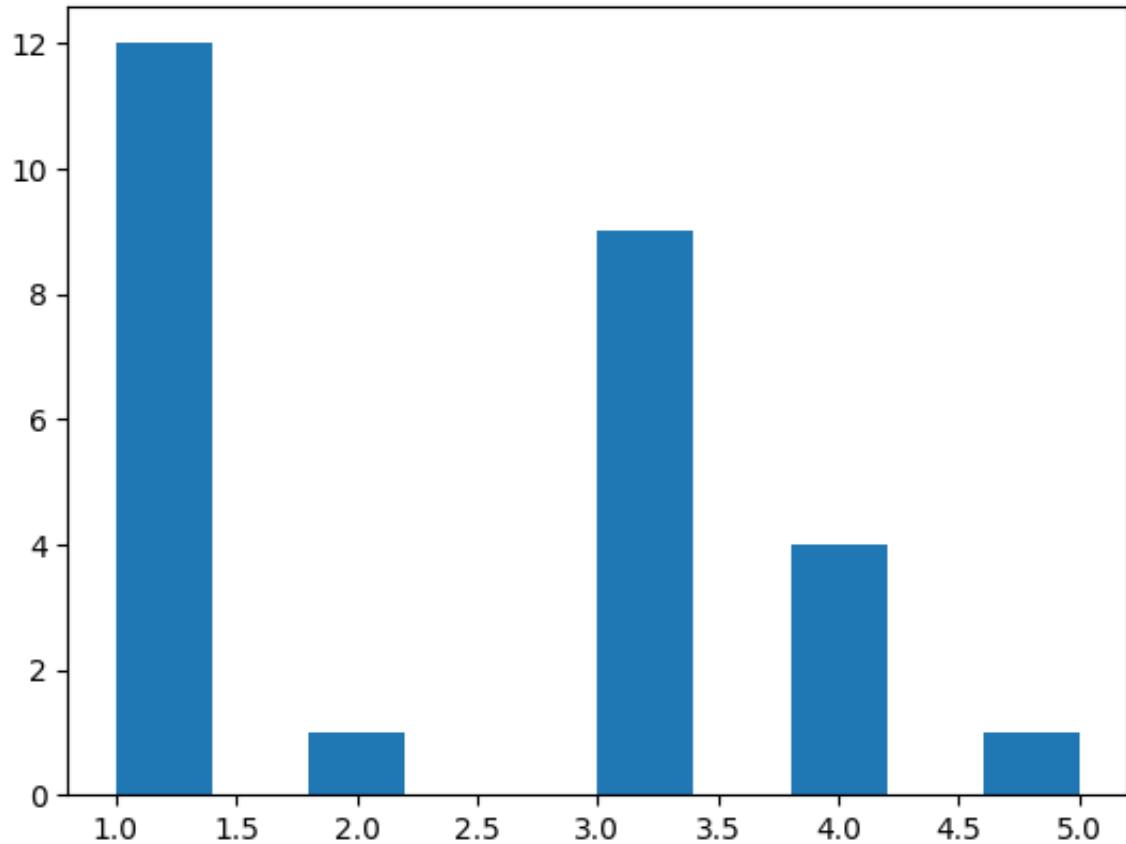
Size of the largest connected component: 27

Degree assortativity coefficient: -0.16279069767441873

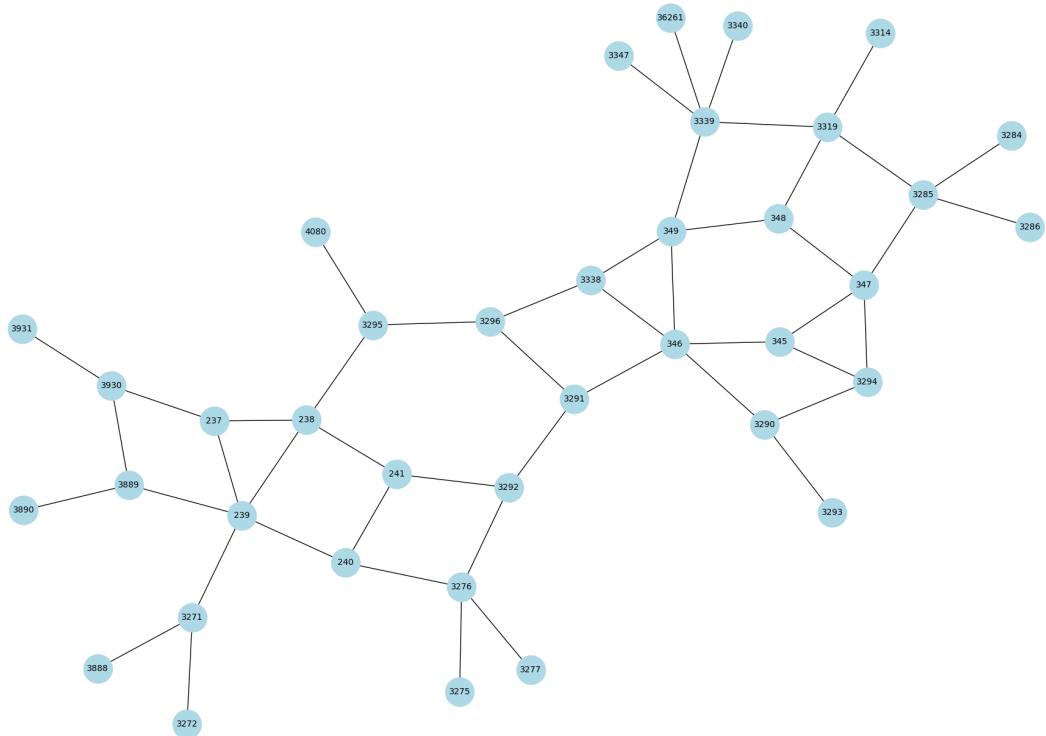
	Node	Degree	Centrality
16	222	0	0.192
14	221	0	0.154
23	7926	0	0.154
17	7918	0	0.154
15	7901	0	0.154
13	220	0	0.115
25	7931	0	0.115
4	4899	0	0.115
20	7923	0	0.115
19	7922	0	0.115
10	217	0	0.115
11	218	0	0.115
12	219	0	0.115
1	4895	0	0.115
26	7932	0	0.077
9	43222	0	0.038
8	7888	0	0.038
7	7887	0	0.038
18	7921	0	0.038
6	7882	0	0.038
5	7881	0	0.038
21	7924	0	0.038
22	7925	0	0.038
3	4898	0	0.038

24	7927	0.038
2	4896	0.038
0	7937	0.038
	Node	Closeness Centrality
14	221	0.413
16	222	0.406
13	220	0.366
10	217	0.347
17	7918	0.325
15	7901	0.325
1	4895	0.321
12	219	0.317
23	7926	0.313
11	218	0.313
4	4899	0.310
25	7931	0.292
26	7932	0.277
22	7925	0.260
19	7922	0.257
20	7923	0.255
8	7888	0.248
7	7887	0.248
6	7882	0.248
5	7881	0.248
2	4896	0.245
9	43222	0.241
24	7927	0.241
3	4898	0.239
0	7937	0.228
18	7921	0.206
21	7924	0.205
	Node	Betweenness Centrality
16	222	0.480
14	221	0.452
13	220	0.273
10	217	0.223
15	7901	0.194
12	219	0.192
17	7918	0.181
11	218	0.177
23	7926	0.151
1	4895	0.122
19	7922	0.105
20	7923	0.102
25	7931	0.098
4	4899	0.077
26	7932	0.018
9	43222	0.000
8	7888	0.000
7	7887	0.000
18	7921	0.000
6	7882	0.000
5	7881	0.000
21	7924	0.000
22	7925	0.000
3	4898	0.000
24	7927	0.000

2	4896	0.000
0	7937	0.000
	Node	Katz Centrality
16	222	0.220
14	221	0.211
23	7926	0.208
17	7918	0.208
15	7901	0.207
13	220	0.200
4	4899	0.200
1	4895	0.200
10	217	0.199
11	218	0.199
12	219	0.199
25	7931	0.198
20	7923	0.198
19	7922	0.198
26	7932	0.189
9	43222	0.180
8	7888	0.180
7	7887	0.180
6	7882	0.180
5	7881	0.180
24	7927	0.180
18	7921	0.179
21	7924	0.179
22	7925	0.179
3	4898	0.179
2	4896	0.179
0	7937	0.179



----- Graph 6 -----



----- Graph Stats -----

Nodes : 38 Edges : 38

Diameter : 11

Periphery : [3888, 3890, 3272, 3284, 3286, 3931]

Density of the graph: 0.06970128022759602

Average degree: 2.5789473684210527

Size of the largest connected component: 38

Degree assortativity coefficient: -0.23213738117141988

	Node	Degree	Centrality
21	346		0.135
32	239		0.135
1	3339		0.135
37	3319		0.108
11	3276		0.108
31	238		0.108
14	3285		0.108
27	347		0.108
24	349		0.108
22	3295		0.081
23	3296		0.081
26	348		0.081
25	3290		0.081
28	3294		0.081
30	237		0.081
33	240		0.081
34	241		0.081
20	3292		0.081
0	3338		0.081
18	3291		0.081
6	3889		0.081
16	345		0.081
8	3271		0.081
17	3930		0.081

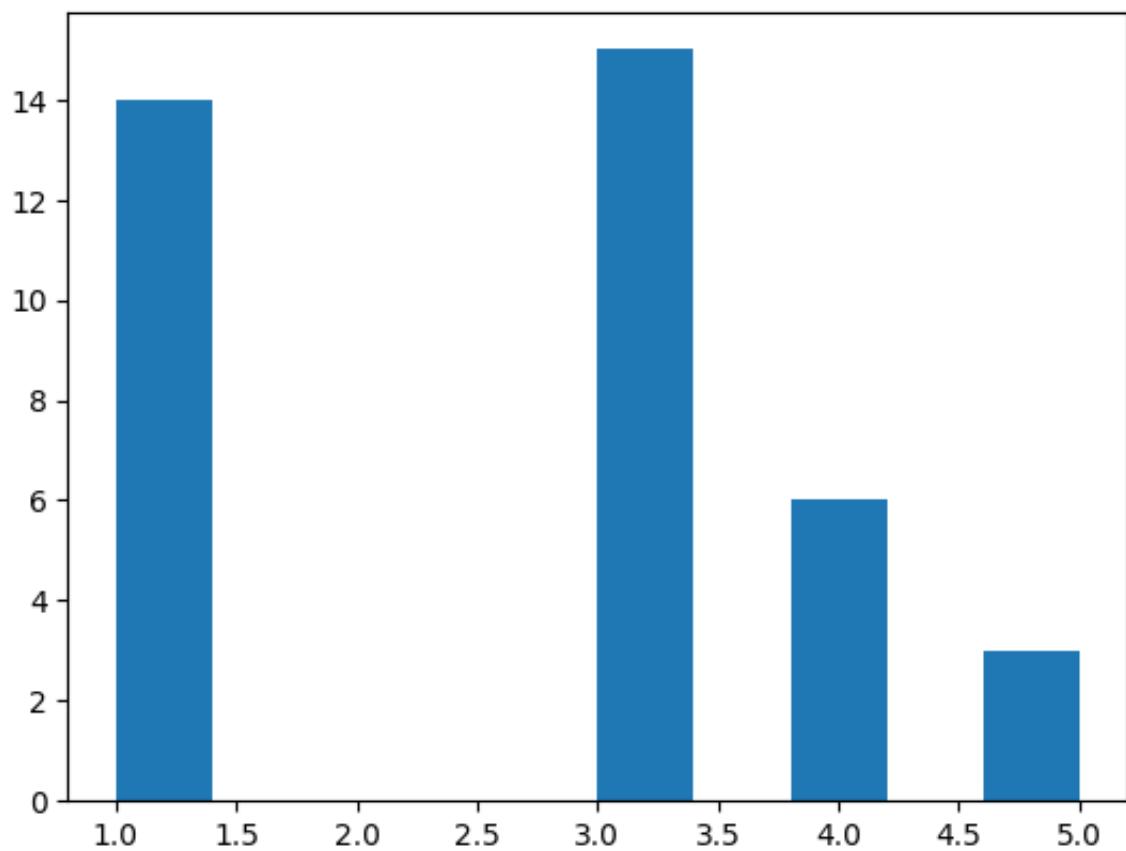
36	3314	0.027
35	4080	0.027
2	3340	0.027
3	3347	0.027
4	36261	0.027
5	3888	0.027
7	3890	0.027
29	3293	0.027
9	3272	0.027
10	3275	0.027
12	3277	0.027
13	3284	0.027
15	3286	0.027
19	3931	0.027
	Node	Closeness Centrality
18	3291	0.287
21	346	0.282
23	3296	0.282
0	3338	0.278
20	3292	0.274
24	349	0.274
22	3295	0.262
34	241	0.255
31	238	0.252
11	3276	0.247
16	345	0.240
1	3339	0.239
26	348	0.237
25	3290	0.233
33	240	0.231
32	239	0.228
30	237	0.219
27	347	0.218
37	3319	0.210
35	4080	0.209
28	3294	0.207
12	3277	0.199
10	3275	0.199
14	3285	0.195
2	3340	0.194
3	3347	0.194
4	36261	0.194
6	3889	0.193
8	3271	0.191
29	3293	0.190
17	3930	0.186
36	3314	0.175
15	3286	0.164
13	3284	0.164
7	3890	0.162
5	3888	0.161
9	3272	0.161
19	3931	0.157
	Node	Betweenness Centrality
21	346	0.337
31	238	0.298
24	349	0.298

22	3295	0.291
23	3296	0.286
18	3291	0.272
32	239	0.266
0	3338	0.232
20	3292	0.222
1	3339	0.205
11	3276	0.141
27	347	0.118
14	3285	0.116
16	345	0.114
37	3319	0.107
8	3271	0.107
33	240	0.093
34	241	0.089
30	237	0.087
26	348	0.079
25	3290	0.072
6	3889	0.066
17	3930	0.056
28	3294	0.018
29	3293	0.000
36	3314	0.000
35	4080	0.000
2	3340	0.000
3	3347	0.000
15	3286	0.000
4	36261	0.000
13	3284	0.000
5	3888	0.000
7	3890	0.000
9	3272	0.000
10	3275	0.000
12	3277	0.000
19	3931	0.000

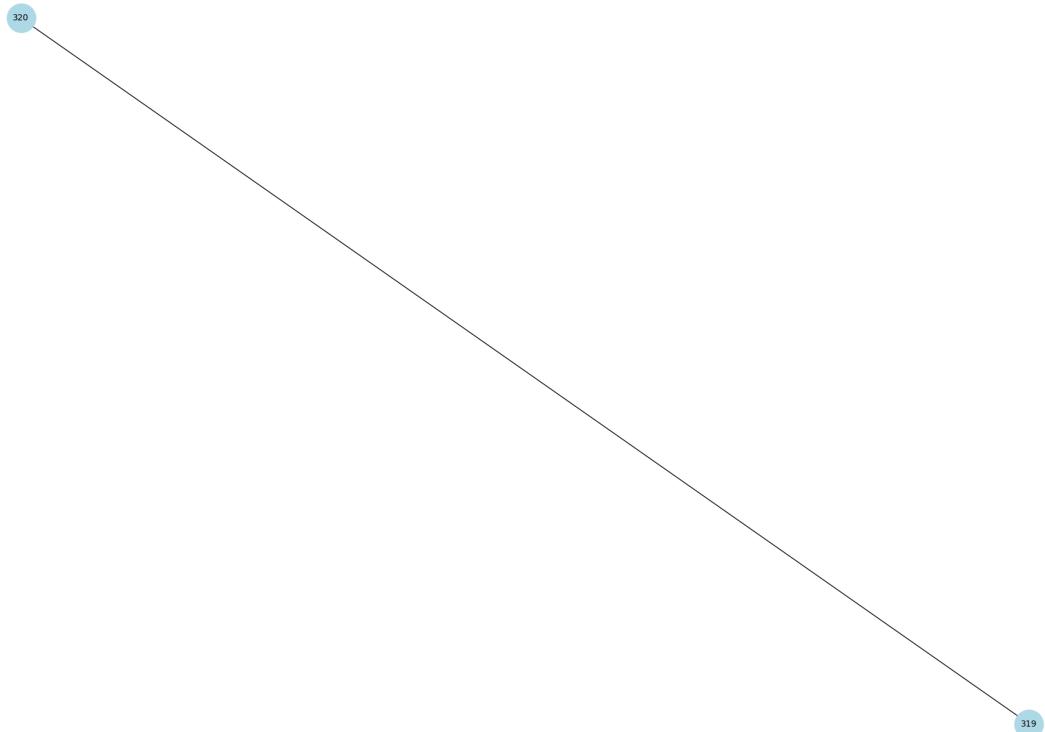
Node Katz Centrality

32	239	0.182
21	346	0.182
1	3339	0.180
24	349	0.175
37	3319	0.174
31	238	0.174
27	347	0.174
14	3285	0.173
11	3276	0.172
16	345	0.166
34	241	0.166
33	240	0.166
30	237	0.166
26	348	0.166
18	3291	0.166
0	3338	0.166
20	3292	0.165
22	3295	0.165
23	3296	0.165
25	3290	0.165
28	3294	0.165

6	3889	0.165
8	3271	0.164
17	3930	0.164
15	3286	0.149
5	3888	0.149
36	3314	0.149
35	4080	0.149
2	3340	0.149
3	3347	0.149
4	36261	0.149
7	3890	0.149
29	3293	0.149
9	3272	0.149
10	3275	0.149
12	3277	0.149
13	3284	0.149
19	3931	0.149



----- Graph 7 -----



----- Graph Stats -----

Nodes : 2 Edges : 2
Diameter : 1
Periphery : [320, 319]
Density of the graph: 1.0
Average degree: 1.0
Size of the largest connected component: 2
Degree assortativity coefficient: nan

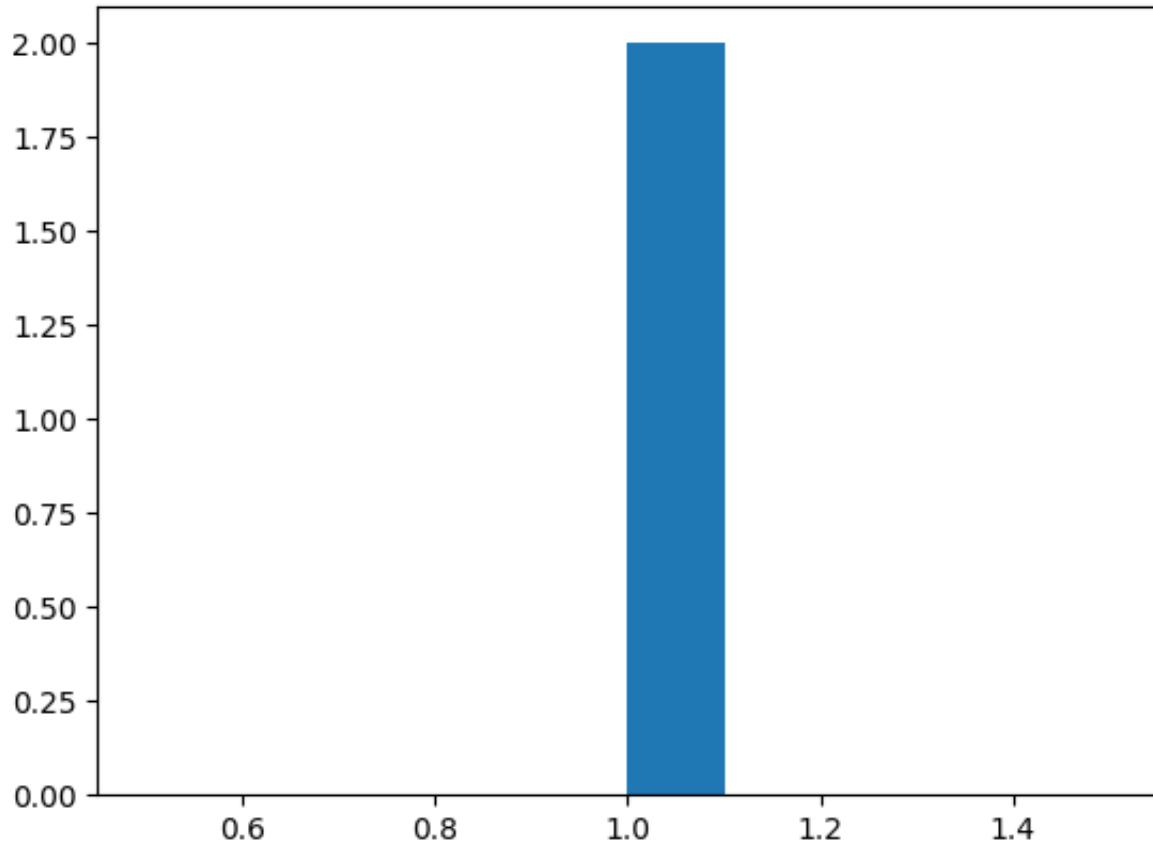
Node	Degree	Centrality
0	320	1.0
1	319	1.0

Node	Closeness	Centrality
0	320	1.0
1	319	1.0

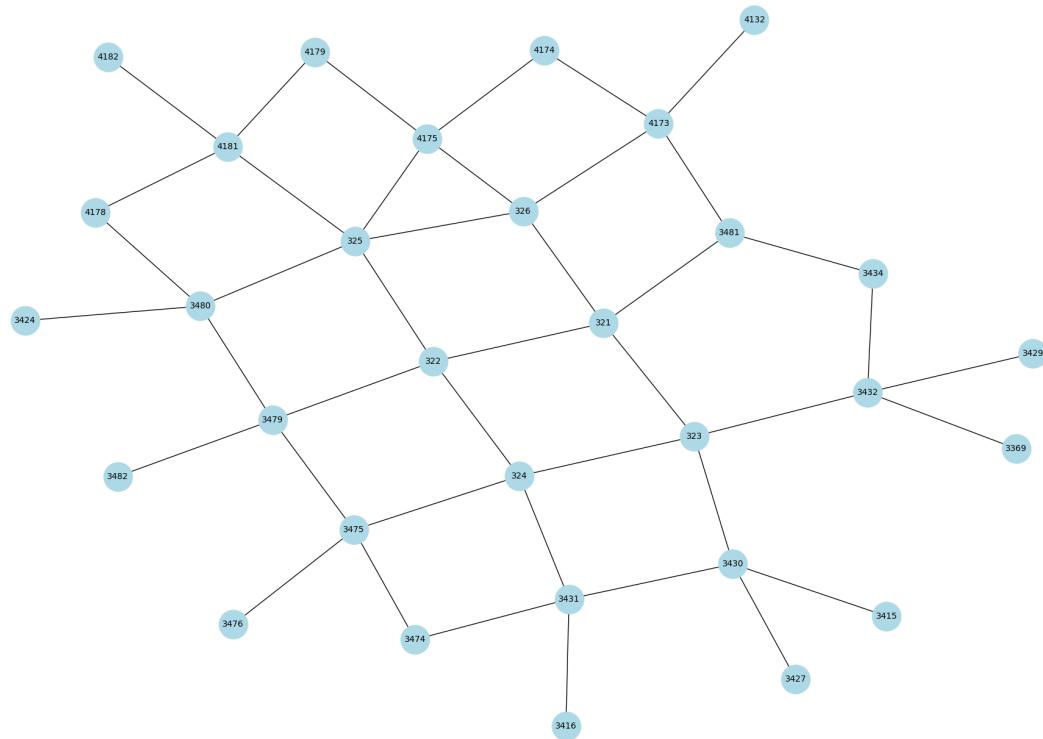
Node	Betweenness	Centrality
0	320	0.0
1	319	0.0

Node	Katz	Centrality
0	320	0.707
1	319	0.707

```
/usr/local/lib/python3.10/dist-packages/networkx/algorithms/assortativity/correlation.py:302: RuntimeWarning: invalid value encountered in scalar divide
    return float((xy * (M - ab)).sum() / np.sqrt(vara * varb))
```



----- Graph 8 -----



----- Graph Stats -----

Nodes : 31 Edges : 31

Diameter : 7

Periphery : [3474, 3476, 4132, 3369, 4178, 4182, 3415, 3416, 3424, 3427, 3429]

Density of the graph: 0.09032258064516129

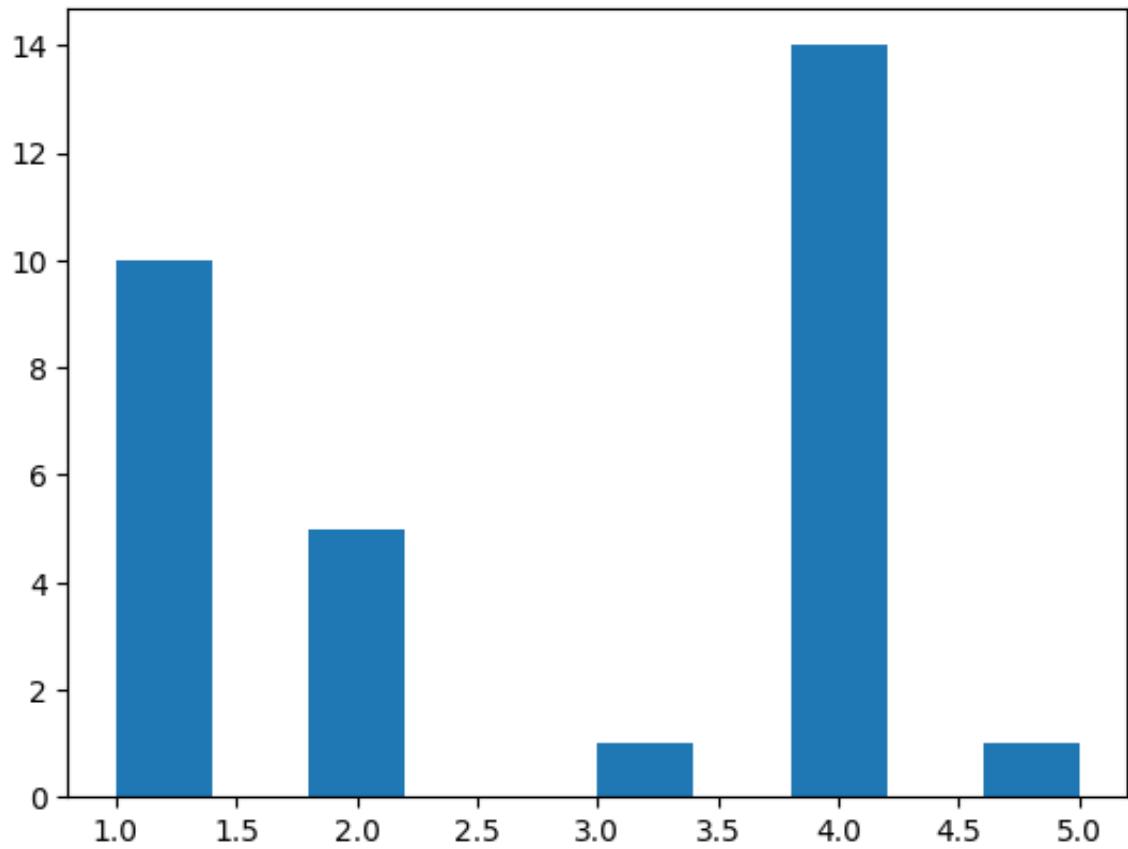
Average degree: 2.7096774193548385
Size of the largest connected component: 31
Degree assortativity coefficient: -0.21188630490956037

Node	Degree	Centrality
13	325	0.167
15	4173	0.133
20	4181	0.133
1	3475	0.133
14	326	0.133
12	324	0.133
11	323	0.133
10	322	0.133
9	321	0.133
27	3430	0.133
28	3431	0.133
4	3480	0.133
3	3479	0.133
29	3432	0.133
17	4175	0.133
5	3481	0.100
18	4178	0.067
19	4179	0.067
0	3474	0.067
16	4174	0.067
30	3434	0.067
8	3369	0.033
21	4182	0.033
22	3415	0.033
23	3416	0.033
24	3424	0.033
25	3427	0.033
26	3429	0.033
7	4132	0.033
6	3482	0.033
2	3476	0.033

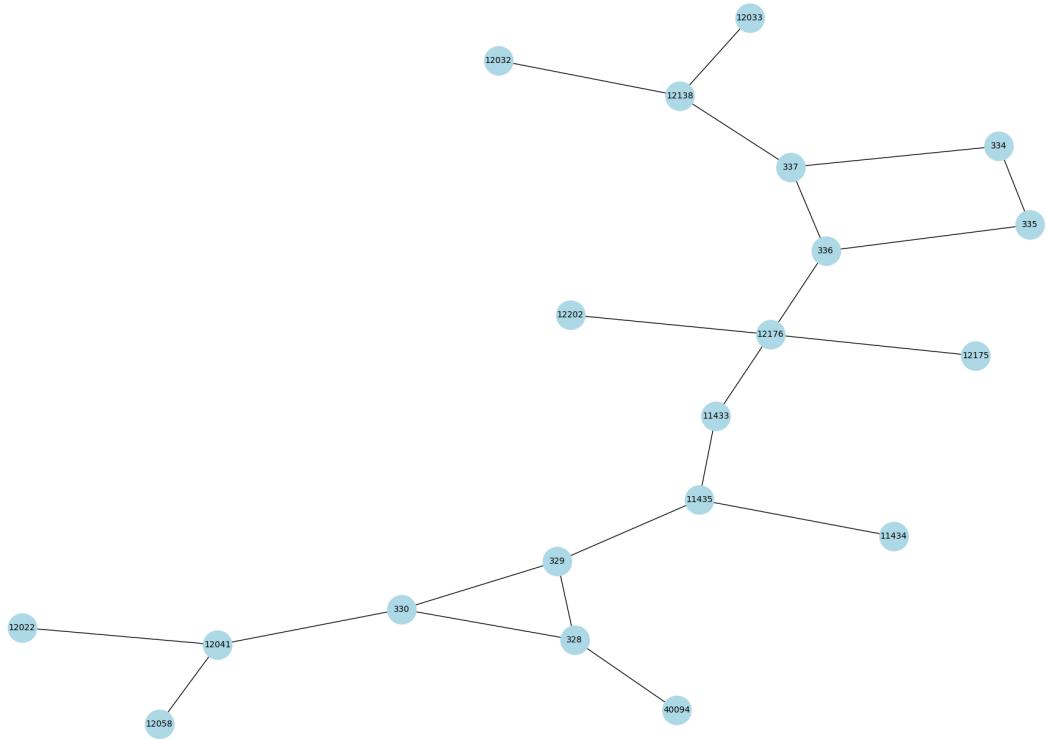
Node	Closeness	Centrality
10	322	0.385
9	321	0.375
12	324	0.366
11	323	0.357
13	325	0.353
14	326	0.345
3	3479	0.323
17	4175	0.309
1	3475	0.309
5	3481	0.306
4	3480	0.300
28	3431	0.297
29	3432	0.291
27	3430	0.291
15	4173	0.286
20	4181	0.278
30	3434	0.270
16	4174	0.261
0	3474	0.259
19	4179	0.250
6	3482	0.246

18	4178	0.244
2	3476	0.238
24	3424	0.233
23	3416	0.231
8	3369	0.227
22	3415	0.227
25	3427	0.227
26	3429	0.227
7	4132	0.224
21	4182	0.219
	Node	Betweenness Centrality
11	323	0.305
13	325	0.273
10	322	0.261
9	321	0.242
12	324	0.236
3	3479	0.175
14	326	0.165
27	3430	0.155
29	3432	0.154
4	3480	0.144
1	3475	0.141
28	3431	0.127
15	4173	0.104
20	4181	0.102
5	3481	0.087
17	4175	0.084
30	3434	0.028
0	3474	0.020
18	4178	0.014
16	4174	0.008
19	4179	0.006
8	3369	0.000
21	4182	0.000
22	3415	0.000
23	3416	0.000
24	3424	0.000
25	3427	0.000
26	3429	0.000
7	4132	0.000
6	3482	0.000
2	3476	0.000
	Node	Katz Centrality
13	325	0.202
10	322	0.193
14	326	0.193
9	321	0.192
12	324	0.192
11	323	0.192
17	4175	0.191
3	3479	0.191
20	4181	0.190
28	3431	0.190
4	3480	0.190
1	3475	0.190
15	4173	0.190
27	3430	0.189

29	3432	0.189
5	3481	0.182
18	4178	0.173
19	4179	0.173
0	3474	0.173
16	4174	0.173
30	3434	0.173
21	4182	0.164
22	3415	0.164
23	3416	0.164
24	3424	0.164
25	3427	0.164
7	4132	0.164
6	3482	0.164
2	3476	0.164
8	3369	0.163
26	3429	0.163



----- Graph 9 -----



----- Graph Stats -----

Nodes : 20 Edges : 20

Diameter : 10

Periphery : [12032, 12033, 12058, 12022]

Density of the graph: 0.11052631578947368

Average degree: 2.1

Size of the largest connected component: 20

Degree assortativity coefficient: -0.4583333333333324

Node	Degree	Centrality
------	--------	------------

4	12176	0.211
13	330	0.158
2	12041	0.158
18	12138	0.158
17	337	0.158
16	336	0.158
9	11435	0.158
11	328	0.158
12	329	0.158
7	11433	0.105
15	335	0.105
14	334	0.105
0	12032	0.053
10	12202	0.053
1	12033	0.053
8	11434	0.053
6	40094	0.053
5	12058	0.053
3	12175	0.053
19	12022	0.053

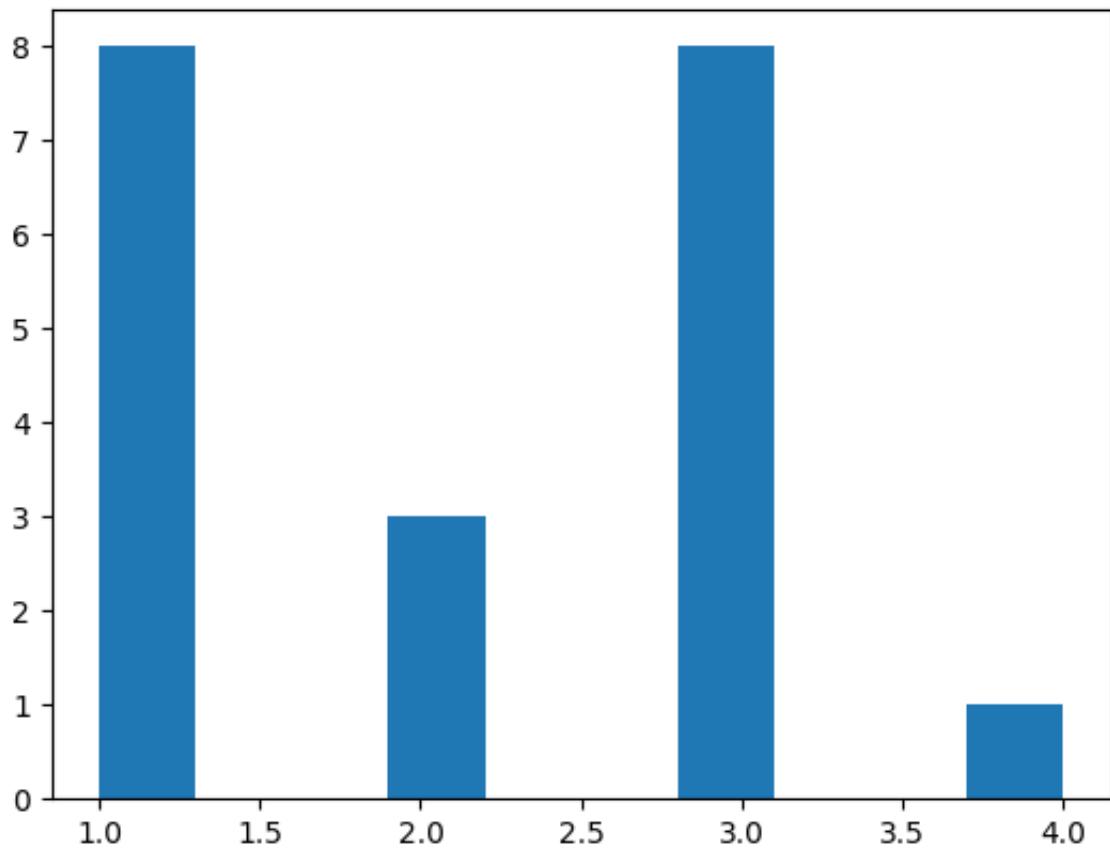
Node	Closeness	Centrality
------	-----------	------------

4	12176	0.317
7	11433	0.317
9	11435	0.306

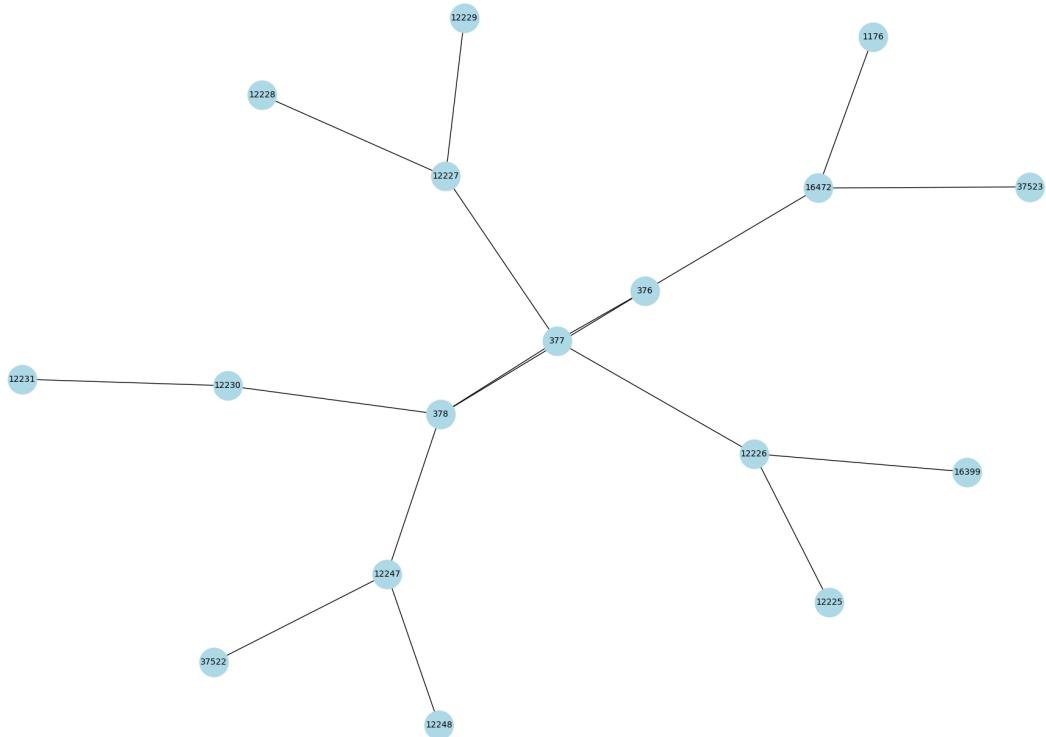
16	336	0.288
12	329	0.279
17	337	0.250
10	12202	0.244
3	12175	0.244
13	330	0.244
8	11434	0.237
11	328	0.237
15	335	0.232
18	12138	0.211
2	12041	0.207
14	334	0.207
6	40094	0.194
0	12032	0.176
1	12033	0.176
5	12058	0.173
19	12022	0.173
	Node Betweenness Centrality	
4	12176	0.614
9	11435	0.556
7	11433	0.526
16	336	0.468
12	329	0.456
17	337	0.322
13	330	0.281
2	12041	0.205
18	12138	0.205
11	328	0.105
15	335	0.041
14	334	0.012
0	12032	0.000
10	12202	0.000
1	12033	0.000
8	11434	0.000
6	40094	0.000
5	12058	0.000
3	12175	0.000
19	12022	0.000
	Node Katz Centrality	
4	12176	0.243
17	337	0.234
16	336	0.234
12	329	0.234
13	330	0.234
9	11435	0.233
11	328	0.233
2	12041	0.232
18	12138	0.232
7	11433	0.223
14	334	0.222
15	335	0.222
10	12202	0.212
3	12175	0.212
0	12032	0.211
1	12033	0.211
8	11434	0.211
6	40094	0.211

5	12058
19	12022

0.211
0.211



Graph 10



----- Graph Stats -----

Nodes : 17 Edges : 17

Diameter : 5

Periphery : [12225, 12228, 12229, 12231, 16399, 37522, 37523, 1176, 1224]

8]

Density of the graph: 0.125

Average degree: 2.0

Size of the largest connected component: 17

Degree assortativity coefficient: -0.00563380281690109

Node Degree Centrality

13	378	0.250
12	377	0.250
10	12247	0.188
2	12227	0.188
14	16472	0.188
1	12226	0.188
11	376	0.188
5	12230	0.125
0	12225	0.062
15	1176	0.062
8	37522	0.062
9	37523	0.062
7	16399	0.062
6	12231	0.062
4	12229	0.062
3	12228	0.062
16	12248	0.062

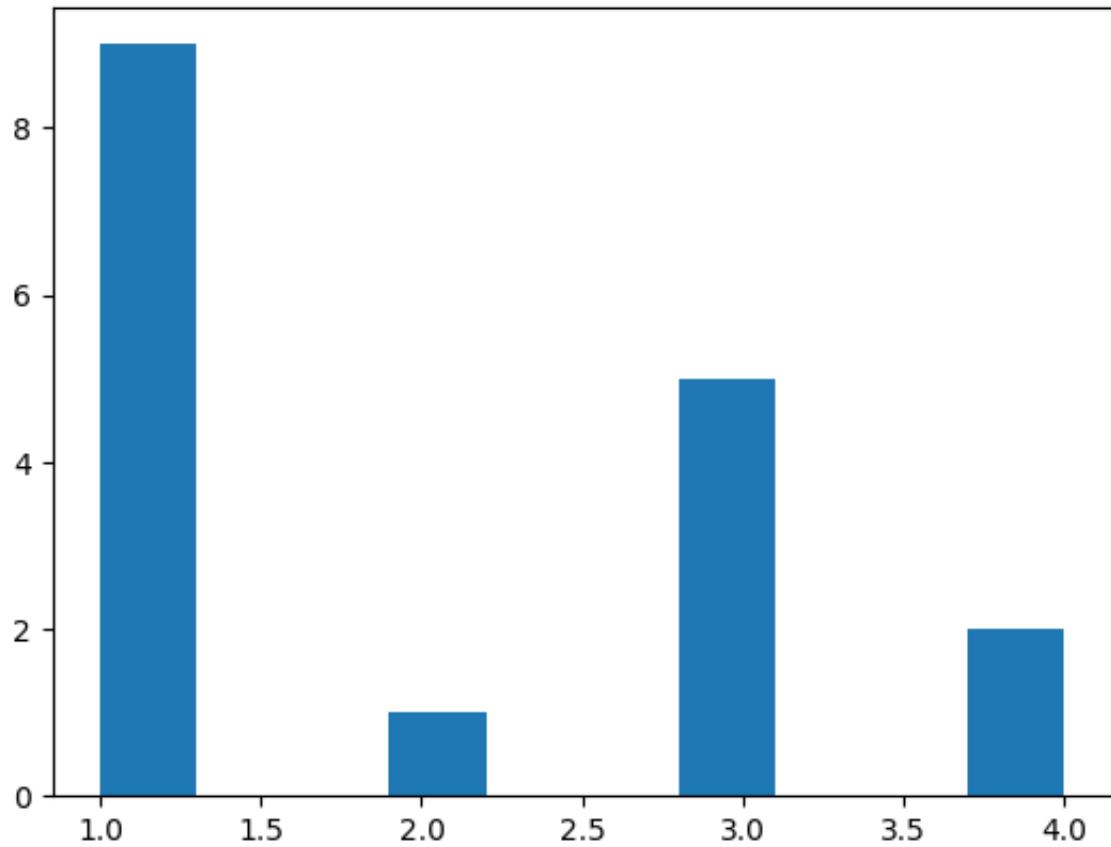
Node Closeness Centrality

12	377	0.485
13	378	0.471
11	376	0.444
2	12227	0.364
1	12226	0.364
10	12247	0.356
5	12230	0.340
14	16472	0.340
0	12225	0.271
3	12228	0.271
4	12229	0.271
7	16399	0.271
8	37522	0.267
16	12248	0.267
9	37523	0.258
6	12231	0.258
15	1176	0.258

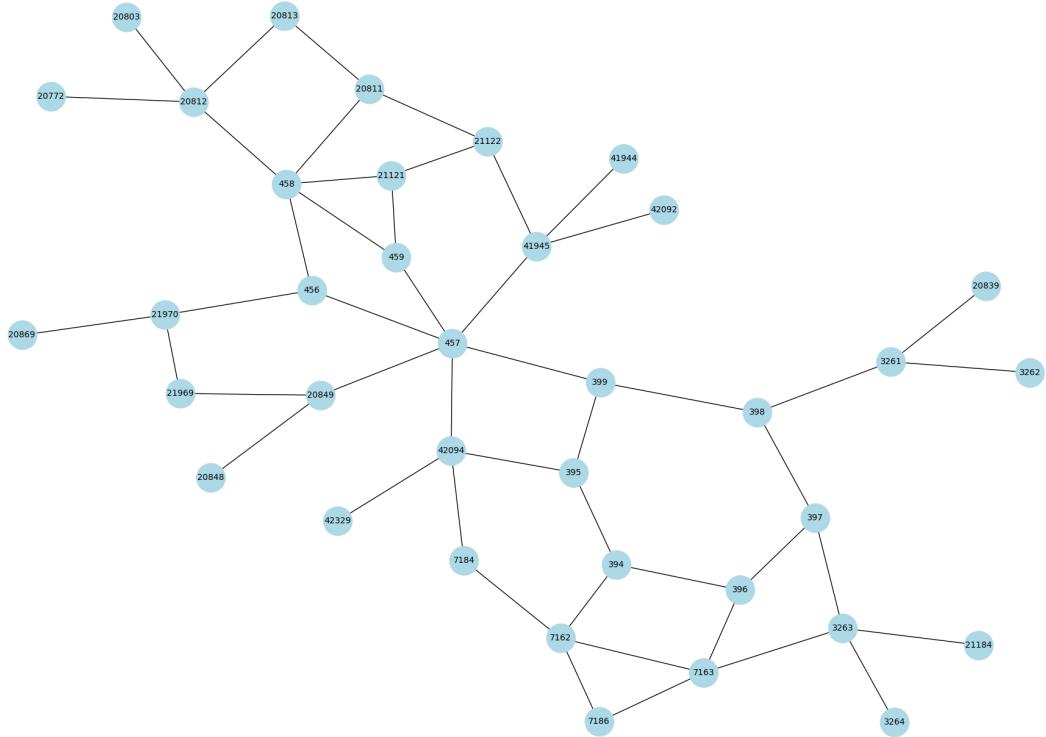
Node Betweenness Centrality

12	377	0.575
13	378	0.508
11	376	0.325
10	12247	0.242
2	12227	0.242
14	16472	0.242
1	12226	0.242
5	12230	0.125
0	12225	0.000
15	1176	0.000
8	37522	0.000
9	37523	0.000
7	16399	0.000
6	12231	0.000
4	12229	0.000

3	12228	0.000
16	12248	0.000
	Node	Katz Centrality
12	377	0.269
13	378	0.268
11	376	0.257
10	12247	0.253
2	12227	0.253
14	16472	0.253
1	12226	0.253
5	12230	0.242
0	12225	0.230
15	1176	0.230
8	37522	0.230
9	37523	0.230
7	16399	0.230
4	12229	0.230
3	12228	0.230
16	12248	0.230
6	12231	0.229



----- Graph 11 -----



----- Graph Stats -----

Nodes : 37 Edges : 37

Diameter : 9

Periphery : [20772, 3264, 21184, 20803, 20813]

Density of the graph: 0.07207207207207207

Average degree: 2.5945945945945947

Size of the largest connected component: 37

Degree assortativity coefficient: -0.15895372233400676

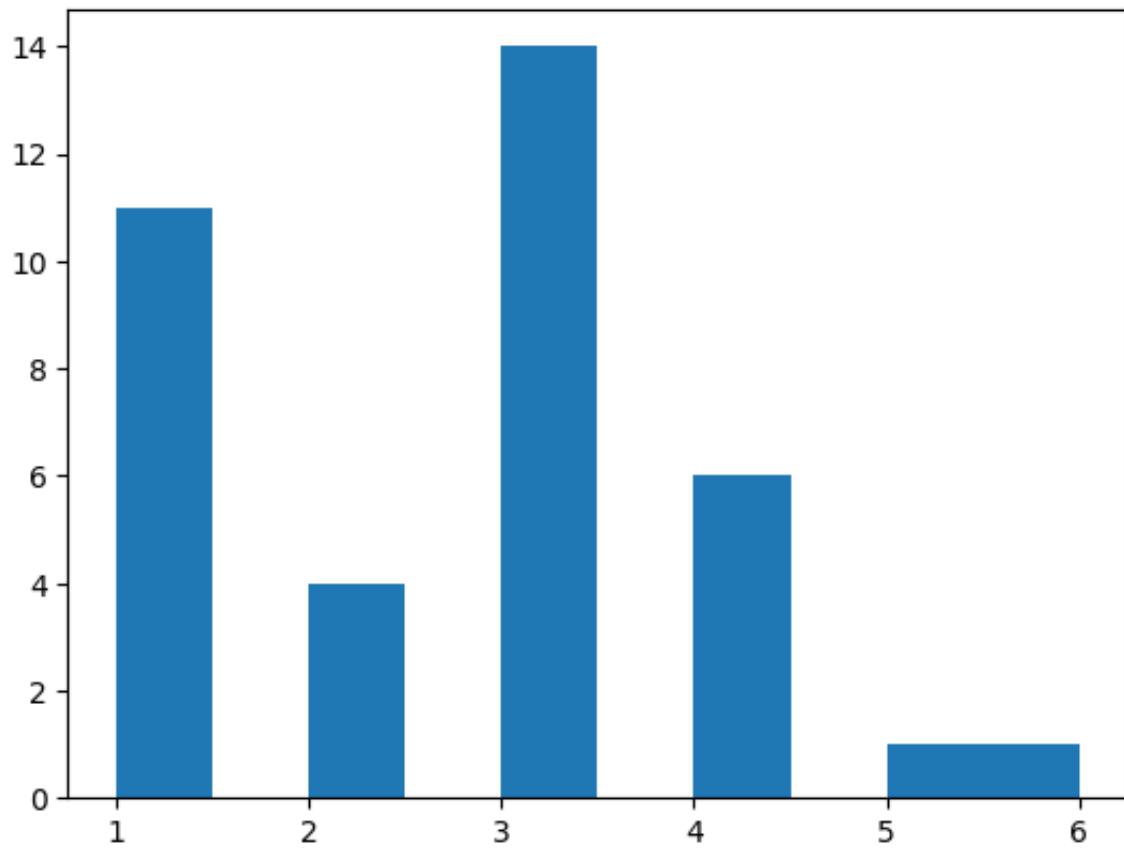
	Node	Degree	Centrality
19	457	0	0.167
20	458	0	0.139
36	7163	0	0.111
14	3263	0	0.111
35	7162	0	0.111
32	42094	0	0.111
29	41945	0	0.111
23	20812	0	0.111
34	20849	0	0.083
26	21970	0	0.083
22	20811	0	0.083
21	459	0	0.083
1	21122	0	0.083
0	21121	0	0.083
18	456	0	0.083
7	398	0	0.083
3	394	0	0.083
4	395	0	0.083
12	3261	0	0.083
5	396	0	0.083
6	397	0	0.083
8	399	0	0.083
24	20813	0	0.056
25	21969	0	0.056

9	7184	0.056
10	7186	0.056
15	3264	0.028
27	41944	0.028
28	42329	0.028
11	20772	0.028
30	20839	0.028
31	42092	0.028
17	20803	0.028
33	20848	0.028
16	21184	0.028
2	20869	0.028
13	3262	0.028
	Node	Closeness Centrality
19	457	0.371
8	399	0.336
32	42094	0.319
18	456	0.316
21	459	0.308
29	41945	0.298
7	398	0.293
34	20849	0.286
4	395	0.286
9	7184	0.271
20	458	0.271
0	21121	0.261
1	21122	0.255
6	397	0.255
26	21970	0.252
3	394	0.250
35	7162	0.247
28	42329	0.243
25	21969	0.240
12	3261	0.234
31	42092	0.231
27	41944	0.231
22	20811	0.228
5	396	0.225
33	20848	0.224
36	7163	0.222
23	20812	0.222
14	3263	0.222
10	7186	0.211
2	20869	0.202
24	20813	0.193
13	3262	0.190
30	20839	0.190
11	20772	0.183
17	20803	0.183
16	21184	0.183
15	3264	0.183
	Node	Betweenness Centrality
19	457	0.608
8	399	0.326
7	398	0.300
32	42094	0.226
20	458	0.223

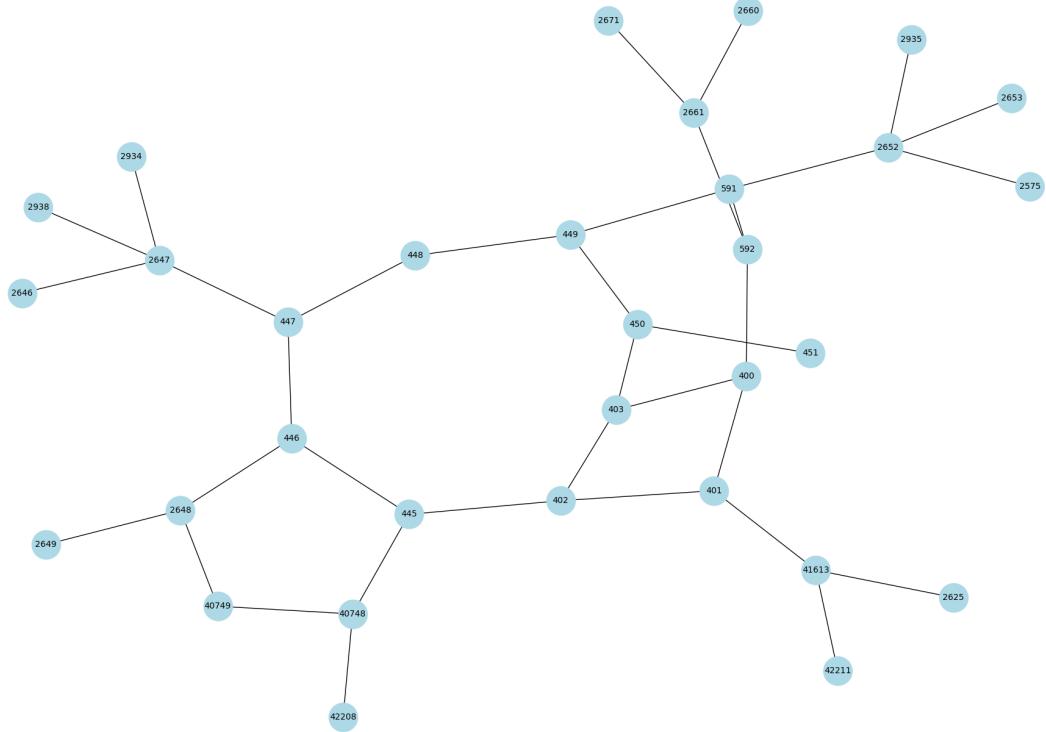
18	456	0.204
29	41945	0.164
6	397	0.159
21	459	0.129
23	20812	0.128
14	3263	0.121
9	7184	0.110
12	3261	0.110
35	7162	0.098
34	20849	0.094
4	395	0.082
26	21970	0.067
36	7163	0.048
3	394	0.046
22	20811	0.045
1	21122	0.044
5	396	0.028
0	21121	0.010
24	20813	0.007
25	21969	0.006
13	3262	0.000
11	20772	0.000
17	20803	0.000
28	42329	0.000
10	7186	0.000
30	20839	0.000
31	42092	0.000
15	3264	0.000
33	20848	0.000
16	21184	0.000
2	20869	0.000
27	41944	0.000

	Node	Katz Centrality
19	457	0.193
20	458	0.184
36	7163	0.176
32	42094	0.176
35	7162	0.175
29	41945	0.175
14	3263	0.174
23	20812	0.174
21	459	0.169
18	456	0.169
5	396	0.168
1	21122	0.168
3	394	0.168
4	395	0.168
22	20811	0.168
6	397	0.168
8	399	0.168
0	21121	0.168
7	398	0.167
34	20849	0.167
12	3261	0.166
26	21970	0.166
10	7186	0.160
9	7184	0.160

24	20813	0.159
25	21969	0.159
28	42329	0.151
31	42092	0.151
17	20803	0.151
16	21184	0.151
11	20772	0.151
15	3264	0.151
27	41944	0.151
13	3262	0.150
30	20839	0.150
33	20848	0.150
2	20869	0.150



----- Graph 12 -----



----- Graph Stats -----

Nodes : 32 Edges : 32

Diameter : 9

Periphery : [2575, 2649, 2653, 42208, 2660, 2671, 2935]

Density of the graph: 0.07056451612903226

Average degree: 2.1875

Size of the largest connected component: 32

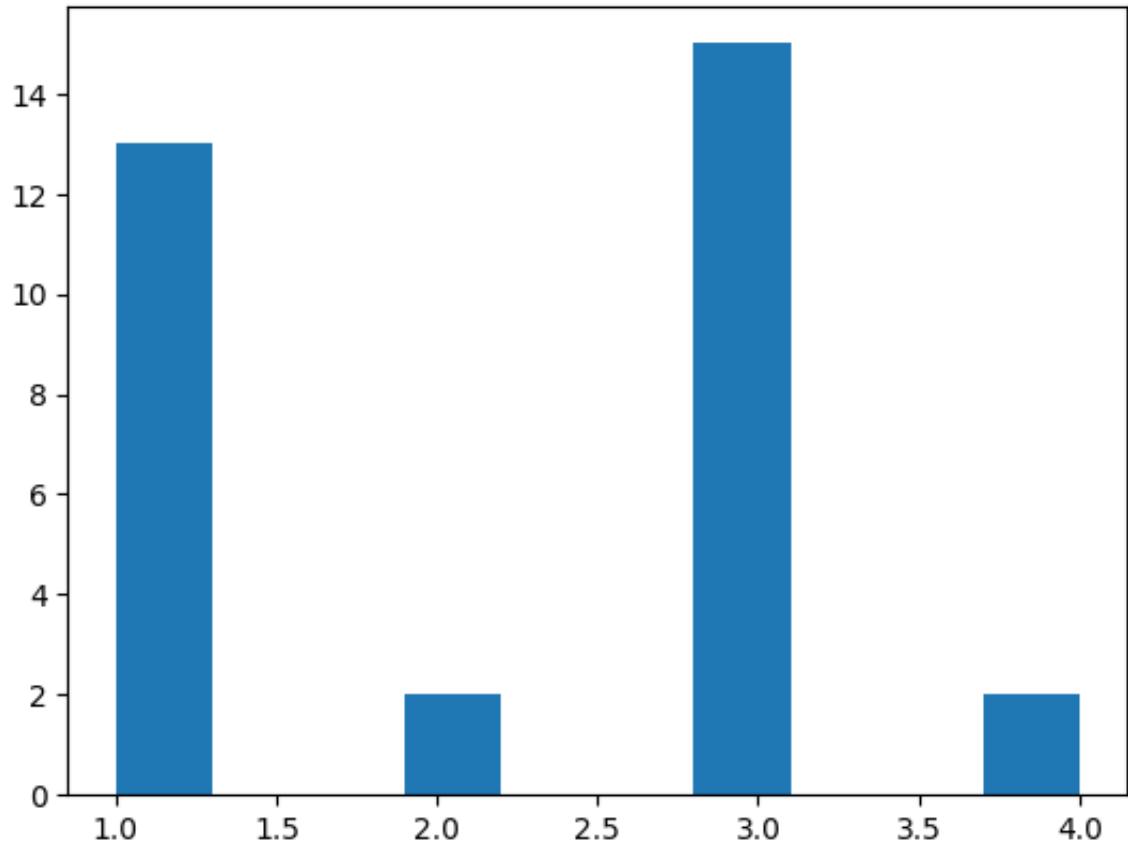
Degree assortativity coefficient: -0.5415415415415425

Node Degree Centrality

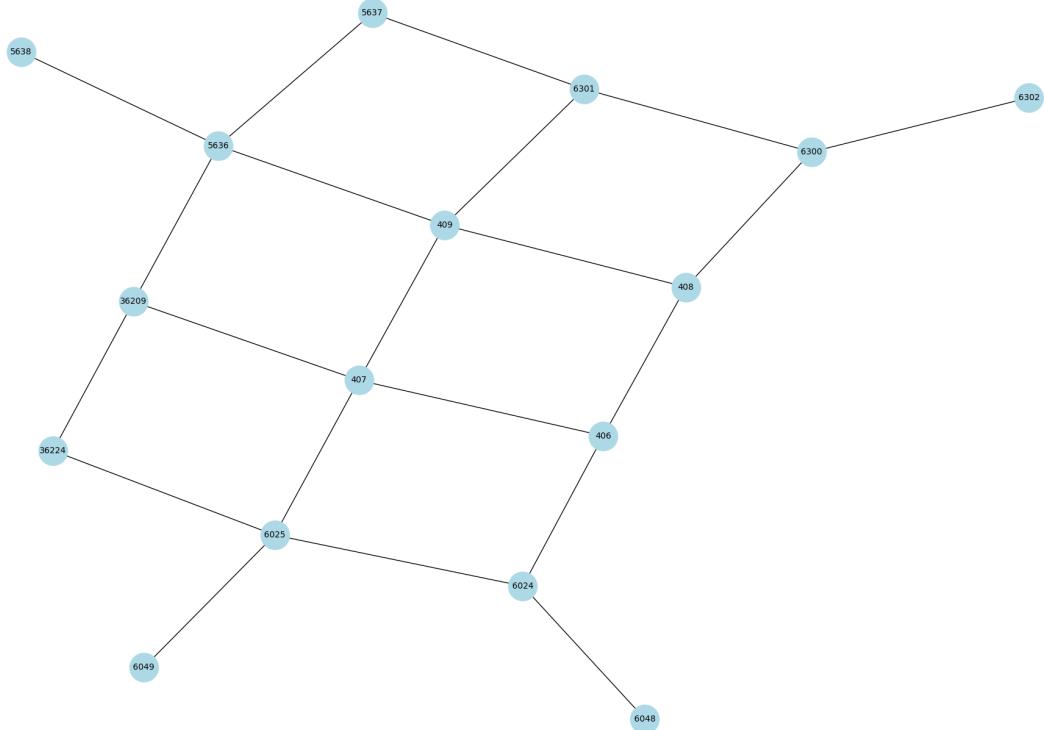
22	2652	0.129
19	2647	0.129
0	41613	0.097
10	447	0.097
27	2661	0.097
20	2648	0.097
17	592	0.097
14	449	0.097
13	450	0.097
16	591	0.097
9	446	0.097
8	445	0.097
6	40748	0.097
2	400	0.097
5	403	0.097
4	402	0.097
3	401	0.097
7	40749	0.065
11	448	0.065
25	42211	0.032
30	2935	0.032
29	2934	0.032
28	2671	0.032
26	2660	0.032

21	2649	0.032
24	42208	0.032
23	2653	0.032
18	2646	0.032
1	2575	0.032
15	451	0.032
12	2625	0.032
31	2938	0.032
	Node	Closeness Centrality
14	449	0.290
4	402	0.287
5	403	0.282
16	591	0.279
10	447	0.279
3	401	0.277
11	448	0.274
2	400	0.272
8	445	0.272
17	592	0.272
13	450	0.272
9	446	0.270
22	2652	0.230
19	2647	0.230
0	41613	0.225
6	40748	0.225
20	2648	0.223
27	2661	0.221
15	451	0.215
7	40749	0.205
1	2575	0.188
30	2935	0.188
29	2934	0.188
23	2653	0.188
18	2646	0.188
31	2938	0.188
24	42208	0.185
25	42211	0.185
12	2625	0.185
21	2649	0.183
26	2660	0.182
28	2671	0.182
	Node	Betweenness Centrality
10	447	0.328
16	591	0.320
14	449	0.278
8	445	0.276
17	592	0.273
4	402	0.267
9	446	0.255
3	401	0.234
11	448	0.218
2	400	0.206
22	2652	0.187
19	2647	0.187
5	403	0.144
27	2661	0.127
0	41613	0.127

13	450	0.113
6	40748	0.095
20	2648	0.092
7	40749	0.009
15	451	0.000
25	42211	0.000
30	2935	0.000
29	2934	0.000
28	2671	0.000
26	2660	0.000
23	2653	0.000
24	42208	0.000
1	2575	0.000
21	2649	0.000
12	2625	0.000
18	2646	0.000
31	2938	0.000
	Node	Katz Centrality
22	2652	0.191
19	2647	0.191
16	591	0.185
14	449	0.184
2	400	0.184
3	401	0.184
4	402	0.184
5	403	0.184
8	445	0.184
9	446	0.184
10	447	0.184
17	592	0.184
27	2661	0.183
20	2648	0.183
0	41613	0.183
13	450	0.183
6	40748	0.183
11	448	0.175
7	40749	0.175
15	451	0.166
25	42211	0.166
30	2935	0.166
29	2934	0.166
28	2671	0.166
26	2660	0.166
23	2653	0.166
24	42208	0.166
1	2575	0.166
21	2649	0.166
12	2625	0.166
18	2646	0.166
31	2938	0.166



----- Graph 13 -----



----- Graph Stats -----

Nodes : 16 Edges : 16

Diameter : 6

Periphery : [6048, 6049, 36224, 5637, 5638, 6302]

Density of the graph: 0.175

Average degree: 2.625

Size of the largest connected component: 16
Degree assortativity coefficient: -0.17914438502674013

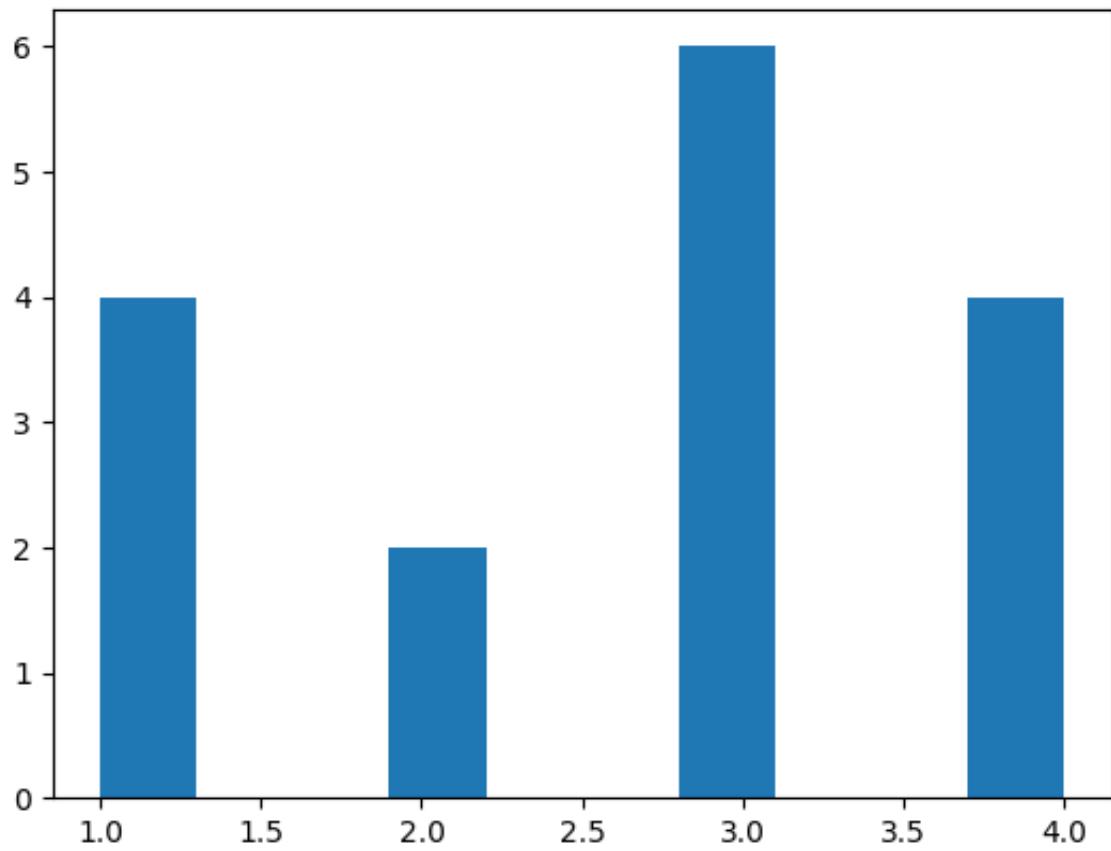
	Node	Degree Centrality
3	5636	0.267
7	6025	0.267
10	407	0.267
12	409	0.267
6	6024	0.200
8	36209	0.200
9	406	0.200
11	408	0.200
13	6300	0.200
14	6301	0.200
2	36224	0.133
4	5637	0.133
0	6048	0.067
1	6049	0.067
5	5638	0.067
15	6302	0.067

	Node	Closeness Centrality
10	407	0.469
12	409	0.469
9	406	0.417
11	408	0.417
3	5636	0.395
7	6025	0.395
8	36209	0.395
14	6301	0.375
6	6024	0.357
2	36224	0.341
13	6300	0.341
4	5637	0.326
1	6049	0.288
5	5638	0.288
0	6048	0.268
15	6302	0.259

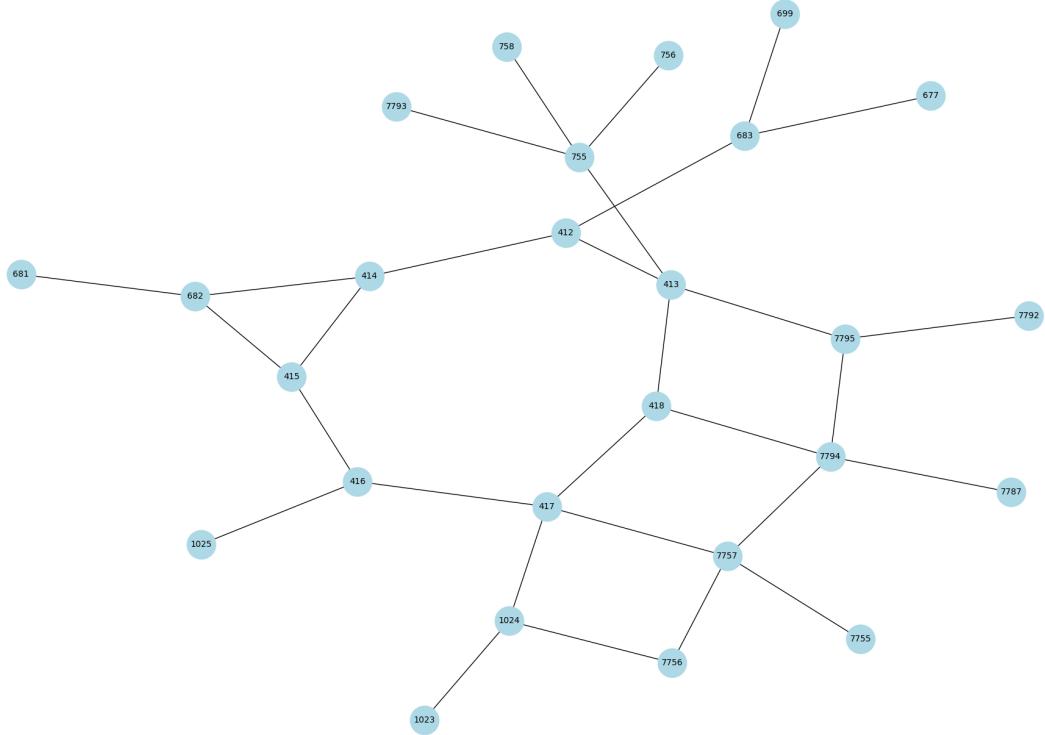
	Node	Betweenness Centrality
10	407	0.304
12	409	0.293
7	6025	0.241
3	5636	0.236
11	408	0.192
9	406	0.190
6	6024	0.165
13	6300	0.153
8	36209	0.147
14	6301	0.118
2	36224	0.042
4	5637	0.033
0	6048	0.000
1	6049	0.000
5	5638	0.000
15	6302	0.000

	Node	Katz Centrality
10	407	0.268
12	409	0.268
3	5636	0.266

7	6025	0.266
8	36209	0.255
9	406	0.255
11	408	0.255
6	6024	0.254
14	6301	0.254
13	6300	0.253
2	36224	0.242
4	5637	0.242
0	6048	0.229
1	6049	0.229
5	5638	0.229
15	6302	0.229



----- Graph 14 -----



----- Graph Stats -----

Nodes : 26 Edges : 26

Diameter : 7

Periphery : [677, 681, 699, 7755, 7756, 7787, 1023]

Density of the graph: 0.09230769230769231

Average degree: 2.3076923076923075

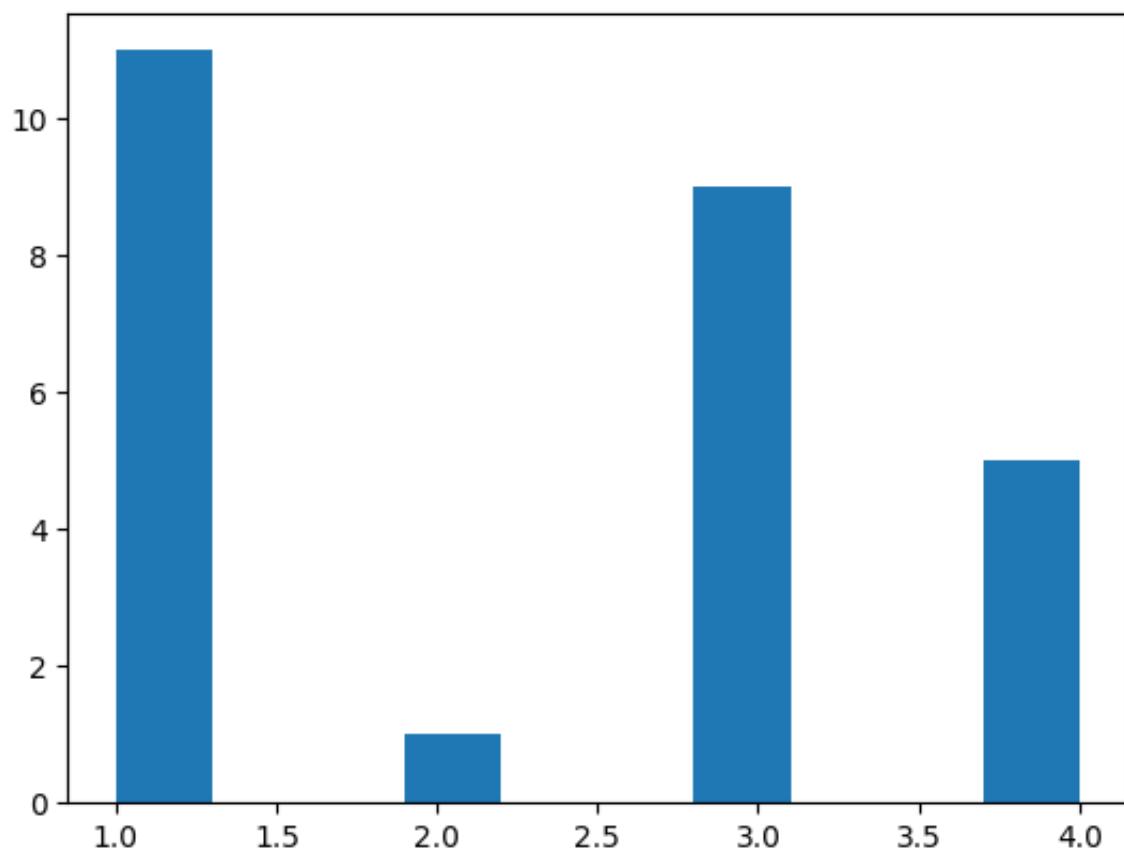
Size of the largest connected component: 26

Degree assortativity coefficient: -0.24746450304259682

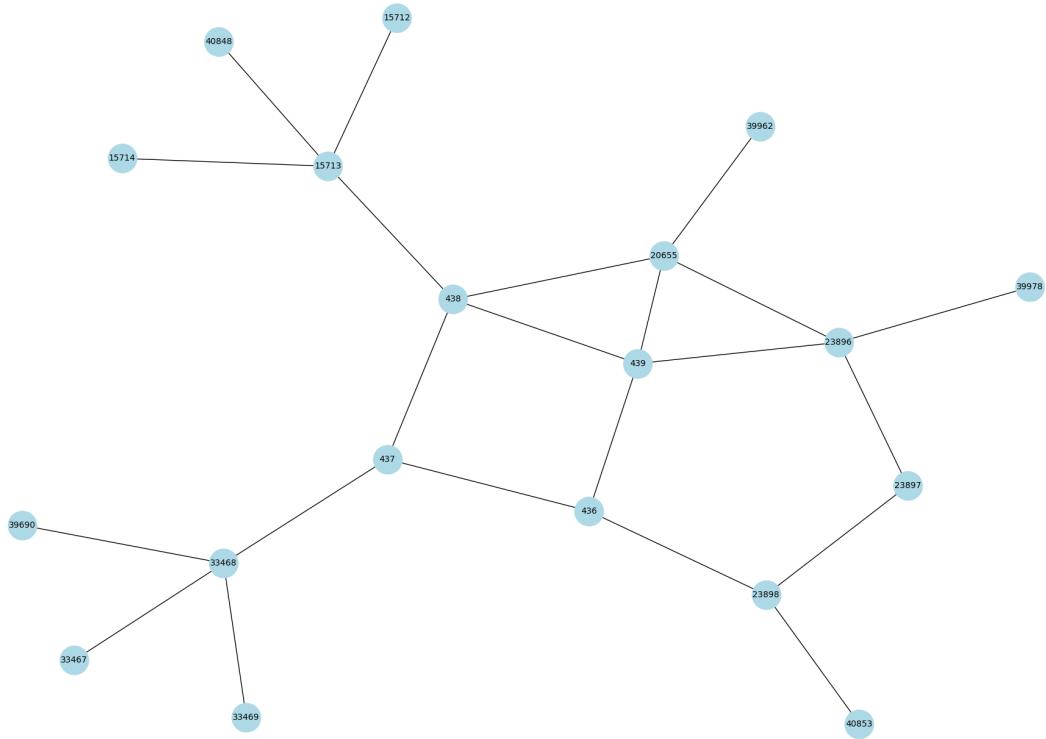
Node	Degree	Centrality
20	7794	0.16
16	7757	0.16
3	413	0.16
21	755	0.16
7	417	0.16
11	682	0.12
22	7795	0.12
12	683	0.12
0	1024	0.12
8	418	0.12
6	416	0.12
5	415	0.12
4	414	0.12
2	412	0.12
15	7756	0.08
19	7793	0.04
23	756	0.04
24	758	0.04
13	699	0.04
18	7792	0.04
17	7787	0.04
14	7755	0.04
1	1025	0.04
10	681	0.04

9	677	0.04
25	1023	0.04
Node Closeness Centrality		
3	413	0.391
8	418	0.373
7	417	0.357
2	412	0.347
22	7795	0.329
20	7794	0.316
4	414	0.312
6	416	0.312
21	755	0.305
16	7757	0.305
5	415	0.301
0	1024	0.278
12	683	0.272
11	682	0.269
18	7792	0.250
15	7756	0.245
17	7787	0.243
1	1025	0.240
14	7755	0.236
23	756	0.236
19	7793	0.236
24	758	0.236
25	1023	0.219
9	677	0.216
13	699	0.216
10	681	0.214
Node Betweenness Centrality		
3	413	0.487
2	412	0.333
7	417	0.319
8	418	0.264
21	755	0.230
20	7794	0.186
6	416	0.180
16	7757	0.169
12	683	0.157
4	414	0.147
22	7795	0.144
5	415	0.117
0	1024	0.100
11	682	0.080
15	7756	0.014
23	756	0.000
19	7793	0.000
24	758	0.000
13	699	0.000
18	7792	0.000
17	7787	0.000
14	7755	0.000
1	1025	0.000
10	681	0.000
9	677	0.000
25	1023	0.000
Node Katz Centrality		

20	7794	0.213
3	413	0.213
16	7757	0.213
7	417	0.213
21	755	0.211
8	418	0.204
2	412	0.203
4	414	0.203
5	415	0.203
22	7795	0.203
11	682	0.202
0	1024	0.202
6	416	0.202
12	683	0.201
15	7756	0.193
23	756	0.183
19	7793	0.183
24	758	0.183
13	699	0.183
18	7792	0.183
17	7787	0.183
14	7755	0.183
1	1025	0.183
10	681	0.183
9	677	0.183
25	1023	0.183



----- Graph 15 -----



----- Graph Stats -----

Nodes : 19 Edges : 19

Diameter : 6

Periphery : [39690, 40848, 40853, 39978, 33467, 33469, 15712, 15714]

Density of the graph: 0.1286549707602339

Average degree: 2.3157894736842106

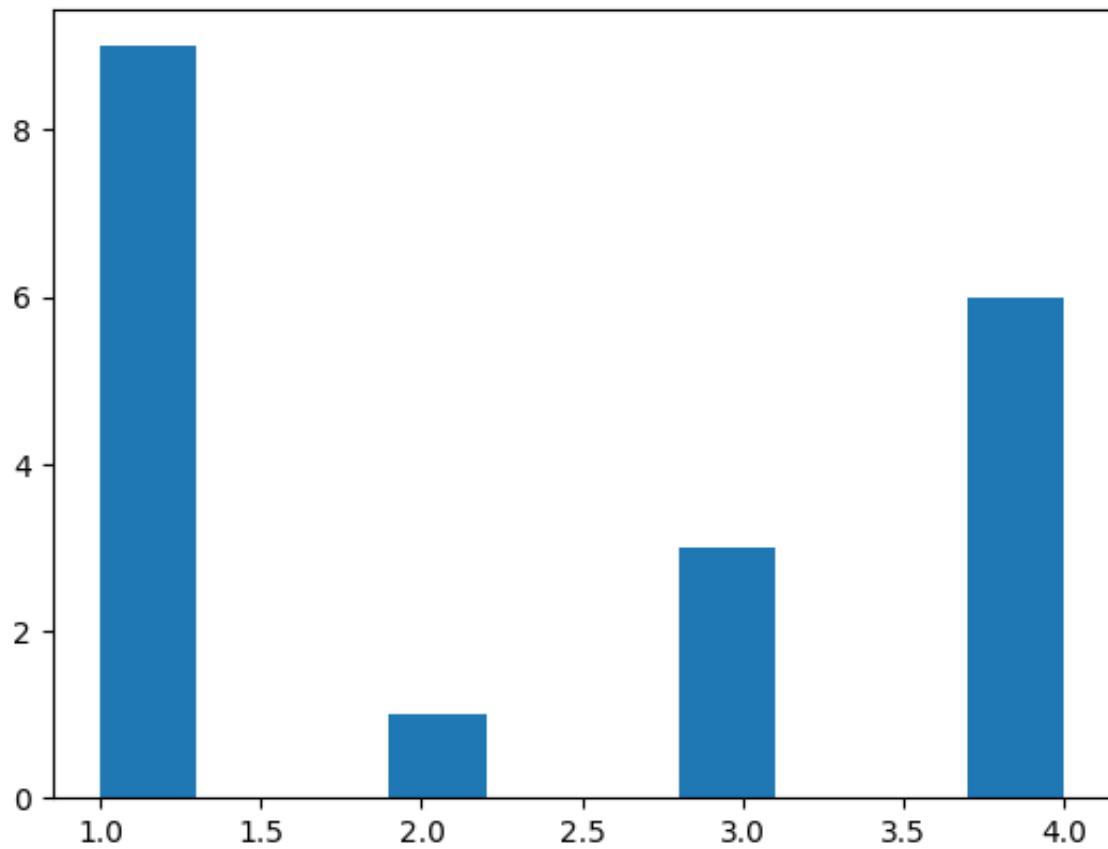
Size of the largest connected component: 19

Degree assortativity coefficient: -0.3628318584070792

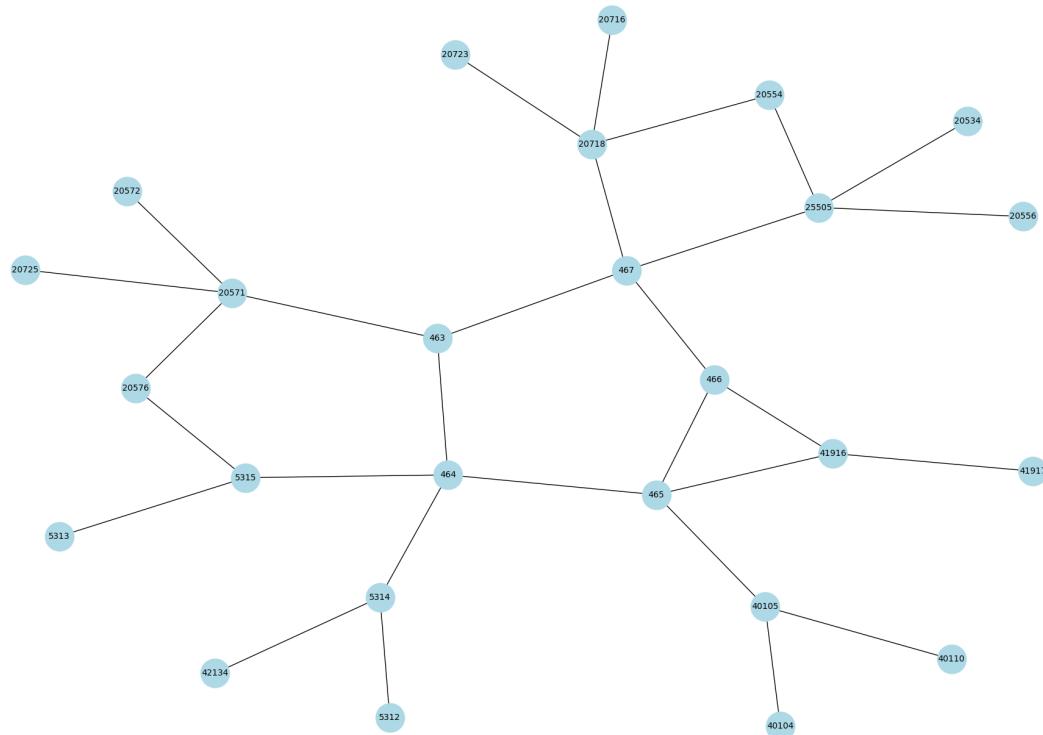
	Node	Degree	Centrality
9	439	0	0.222
17	15713	0	0.222
5	20655	0	0.222
8	438	0	0.222
13	23896	0	0.222
11	33468	0	0.222
15	23898	0	0.167
6	436	0	0.167
7	437	0	0.167
14	23897	0	0.111
12	33469	0	0.056
16	15712	0	0.056
0	39690	0	0.056
10	33467	0	0.056
1	40848	0	0.056
4	39978	0	0.056
3	39962	0	0.056
2	40853	0	0.056
18	15714	0	0.056

	Node	Closeness	Centrality
8	438	0.450	
7	437	0.429	
9	439	0.419	
5	20655	0.400	

6	436	0.400
17	15713	0.353
13	23896	0.346
11	33468	0.340
15	23898	0.321
14	23897	0.305
3	39962	0.290
16	15712	0.265
18	15714	0.265
1	40848	0.265
4	39978	0.261
12	33469	0.257
10	33467	0.257
0	39690	0.257
2	40853	0.247
	Node	Betweenness Centrality
8	438	0.491
7	437	0.415
17	15713	0.314
11	33468	0.314
6	436	0.228
5	20655	0.182
9	439	0.181
13	23896	0.176
15	23898	0.150
14	23897	0.039
12	33469	0.000
16	15712	0.000
0	39690	0.000
10	33467	0.000
1	40848	0.000
4	39978	0.000
3	39962	0.000
2	40853	0.000
18	15714	0.000
	Node	Katz Centrality
9	439	0.251
8	438	0.250
5	20655	0.249
13	23896	0.248
17	15713	0.246
11	33468	0.245
7	437	0.238
6	436	0.237
15	23898	0.235
14	23897	0.226
12	33469	0.214
16	15712	0.214
0	39690	0.214
10	33467	0.214
1	40848	0.214
4	39978	0.214
3	39962	0.214
18	15714	0.214
2	40853	0.213



----- Graph 16 -----



----- Graph Stats -----

Nodes : 26 Edges : 26

Diameter : 6

Periphery : [42134, 40104, 40110, 20534, 41917, 5312, 5313, 20554, 20556, 20572, 20716, 20723, 20725]

Density of the graph: 0.08923076923076922

Average degree: 2.230769230769231

Size of the largest connected component: 26

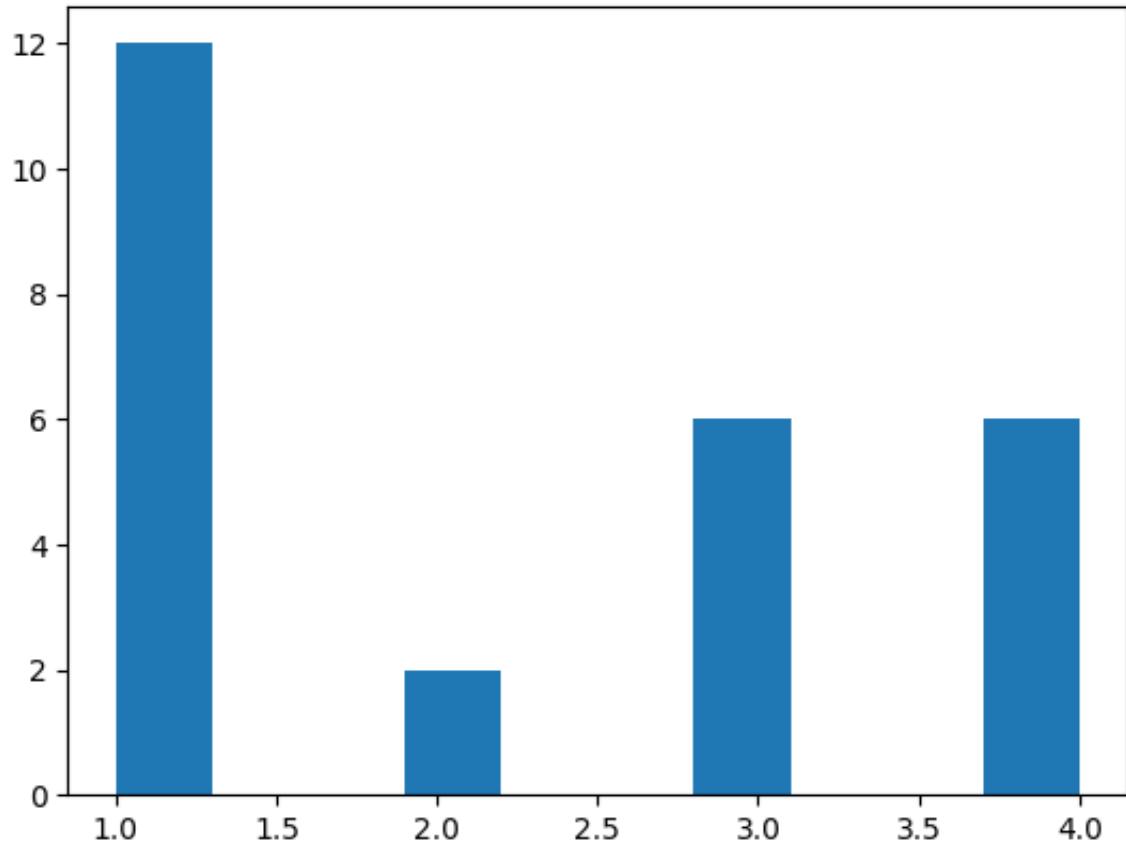
Degree assortativity coefficient: -0.3205828779599262

	Node	Degree	Centrality
19	20571		0.16
18	467		0.16
16	465		0.16
15	464		0.16
23	20718		0.16
1	25505		0.16
14	463		0.12
11	5315		0.12
10	5314		0.12
17	466		0.12
6	41916		0.12
3	40105		0.12
21	20576		0.08
12	20554		0.08
20	20572		0.04
22	20716		0.04
24	20723		0.04
0	42134		0.04
13	20556		0.04
9	5313		0.04
8	5312		0.04
7	41917		0.04
5	20534		0.04
4	40110		0.04
2	40104		0.04
25	20725		0.04

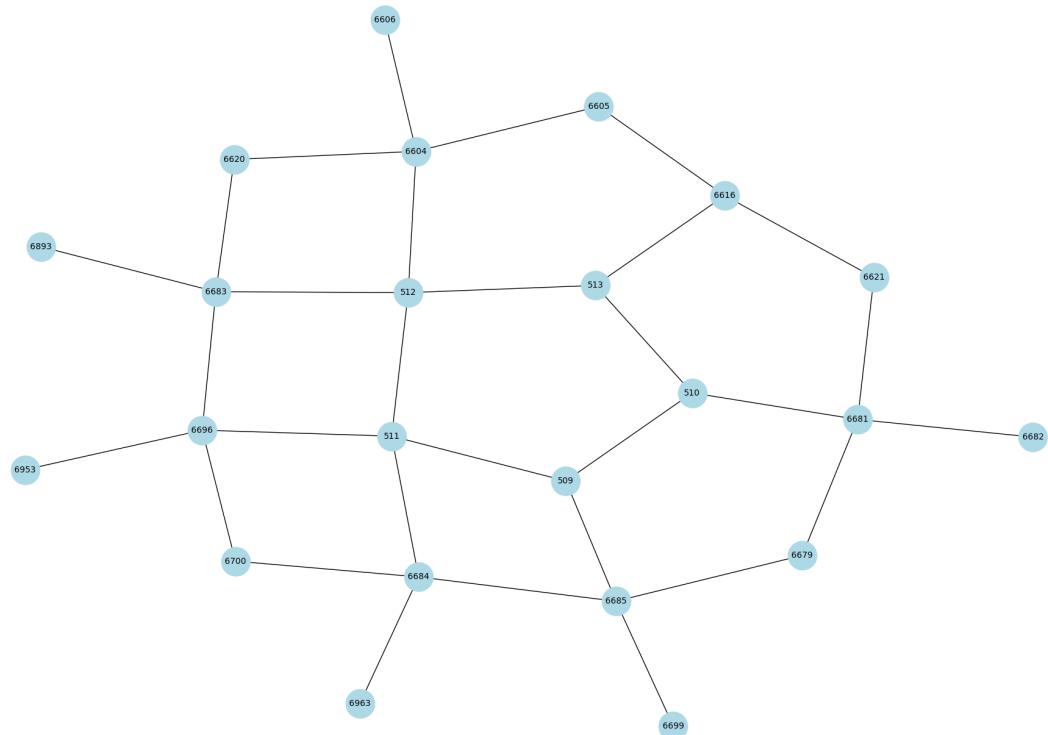
	Node	Closeness	Centrality
18	467		0.397
15	464		0.397
14	463		0.397
16	465		0.373
17	466		0.362
19	20571		0.316
11	5315		0.312
6	41916		0.312
23	20718		0.309
1	25505		0.309
10	5314		0.301
3	40105		0.287
21	20576		0.281
12	20554		0.253
20	20572		0.243
25	20725		0.243
9	5313		0.240
7	41917		0.240
22	20716		0.238
24	20723		0.238
13	20556		0.238
5	20534		0.238
8	5312		0.234
0	42134		0.234
4	40110		0.225
2	40104		0.225

	Node	Betweenness Centrality
18	467	0.463
15	464	0.415
14	463	0.378
16	465	0.302
19	20571	0.188
23	20718	0.188
1	25505	0.188
17	466	0.173
10	5314	0.157
3	40105	0.157
11	5315	0.115
6	41916	0.080
21	20576	0.020
12	20554	0.015
20	20572	0.000
22	20716	0.000
24	20723	0.000
0	42134	0.000
13	20556	0.000
9	5313	0.000
8	5312	0.000
7	41917	0.000
5	20534	0.000
4	40110	0.000
2	40104	0.000
25	20725	0.000

	Node	Katz Centrality
18	467	0.215
16	465	0.214
15	464	0.214
23	20718	0.212
1	25505	0.212
19	20571	0.211
14	463	0.205
17	466	0.205
11	5315	0.203
6	41916	0.203
10	5314	0.202
3	40105	0.202
21	20576	0.194
12	20554	0.194
20	20572	0.184
22	20716	0.184
24	20723	0.184
13	20556	0.184
25	20725	0.184
5	20534	0.184
9	5313	0.183
8	5312	0.183
7	41917	0.183
4	40110	0.183
2	40104	0.183
0	42134	0.183



----- Graph 17 -----



----- Graph Stats -----

Nodes : 23 Edges : 23

Diameter : 6

Periphery : [6679, 6682, 6953, 6699, 6605, 6606, 6620, 6621, 6893]

Density of the graph: 0.11857707509881422

Average degree: 2.608695652173913

Size of the largest connected component: 23

Degree assortativity coefficient: -0.4300518134715037

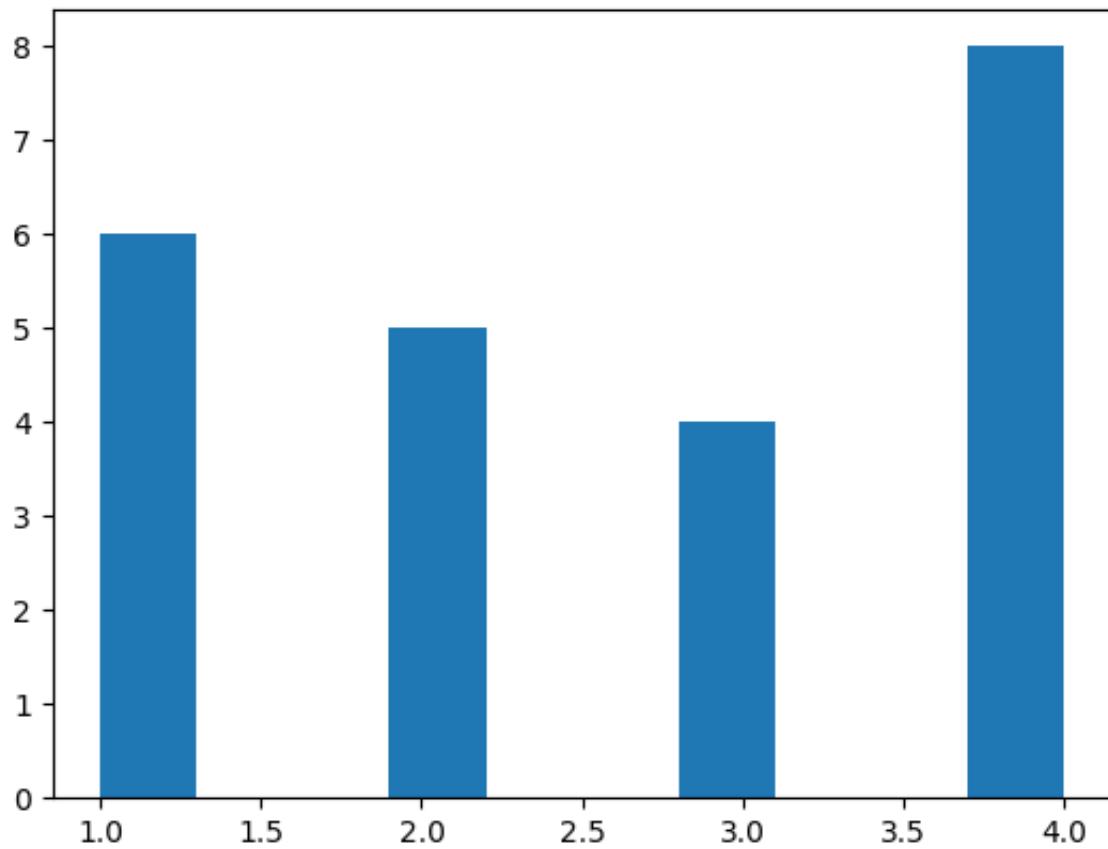
	Node	Degree Centrality
0	512	0.182
6	6684	0.182
13	6604	0.182
8	6696	0.182
7	6685	0.182
22	511	0.182
5	6683	0.182
3	6681	0.182
16	6616	0.136
21	510	0.136
20	509	0.136
1	513	0.136
18	6621	0.091
17	6620	0.091
14	6605	0.091
2	6679	0.091
11	6700	0.091
15	6606	0.045
4	6682	0.045
12	6963	0.045
19	6893	0.045
10	6699	0.045
9	6953	0.045

	Node	Closeness Centrality
0	512	0.423
22	511	0.423
20	509	0.386
1	513	0.386
21	510	0.373
6	6684	0.367
5	6683	0.349
8	6696	0.349
7	6685	0.338
13	6604	0.338
3	6681	0.328
16	6616	0.324
11	6700	0.310
18	6621	0.297
2	6679	0.297
14	6605	0.297
17	6620	0.289
12	6963	0.272
19	6893	0.262
9	6953	0.262
15	6606	0.256
10	6699	0.256
4	6682	0.250

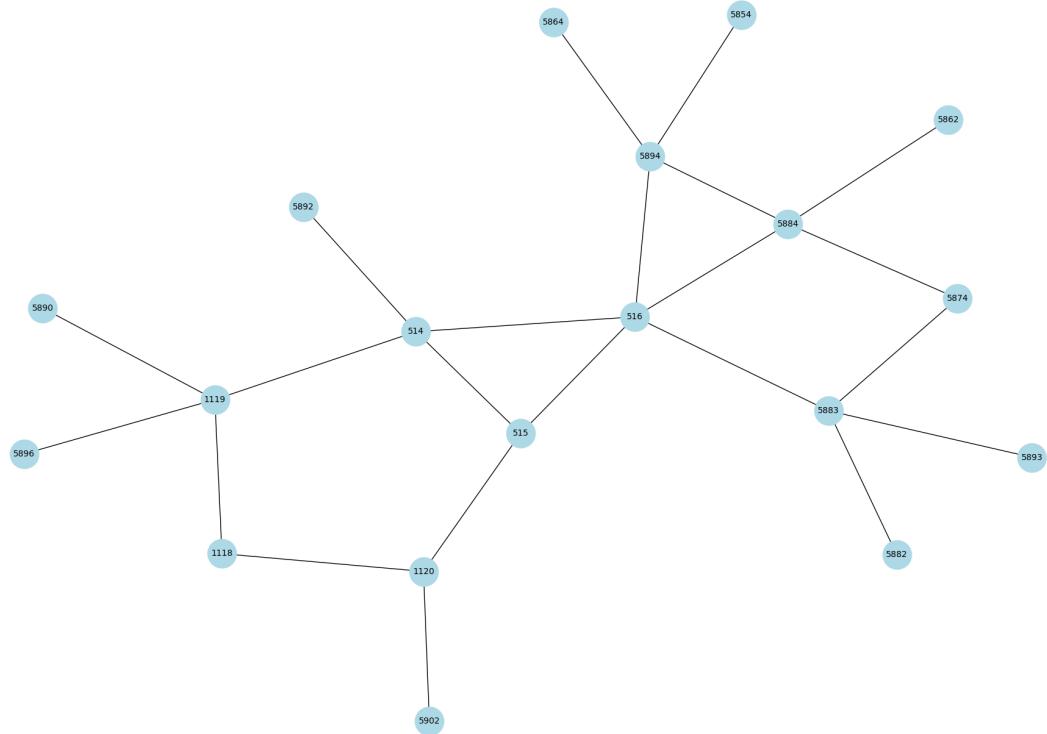
	Node	Betweenness Centrality
0	512	0.314
22	511	0.283
6	6684	0.196
7	6685	0.189
5	6683	0.178
8	6696	0.174

13	6604	0.171
3	6681	0.163
1	513	0.154
20	509	0.130
21	510	0.129
16	6616	0.085
2	6679	0.071
18	6621	0.047
14	6605	0.040
11	6700	0.032
17	6620	0.025
15	6606	0.000
10	6699	0.000
19	6893	0.000
9	6953	0.000
4	6682	0.000
12	6963	0.000

	Node	Katz Centrality
0	512	0.224
22	511	0.224
5	6683	0.222
6	6684	0.222
7	6685	0.222
8	6696	0.222
3	6681	0.221
13	6604	0.221
21	510	0.213
20	509	0.213
1	513	0.213
16	6616	0.211
2	6679	0.202
18	6621	0.202
17	6620	0.202
11	6700	0.202
14	6605	0.202
15	6606	0.191
10	6699	0.191
19	6893	0.191
9	6953	0.191
4	6682	0.191
12	6963	0.191



----- Graph 18 -----



----- Graph Stats -----

Nodes : 19 Edges : 19

Diameter : 5

Periphery : [5890, 5896, 5893, 5902, 1118, 5854, 5862, 5864, 5874, 5882]

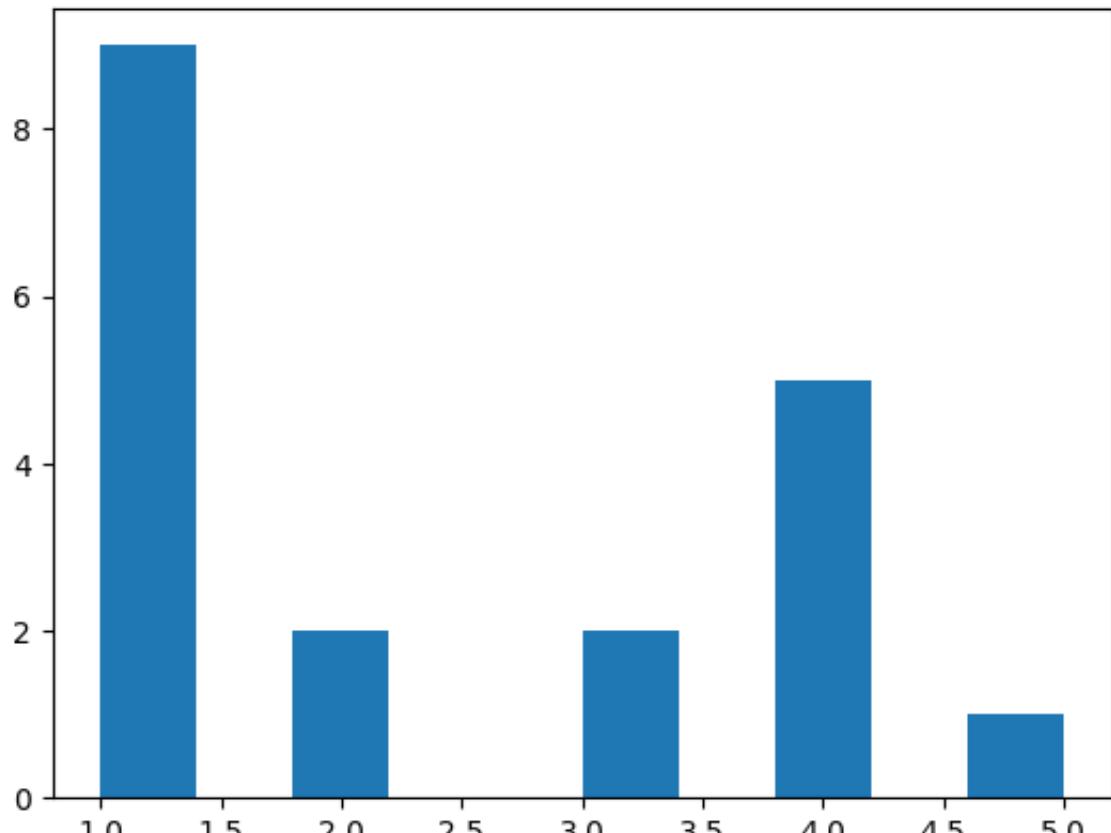
Density of the graph: 0.1286549707602339

Average degree: 2.3157894736842106

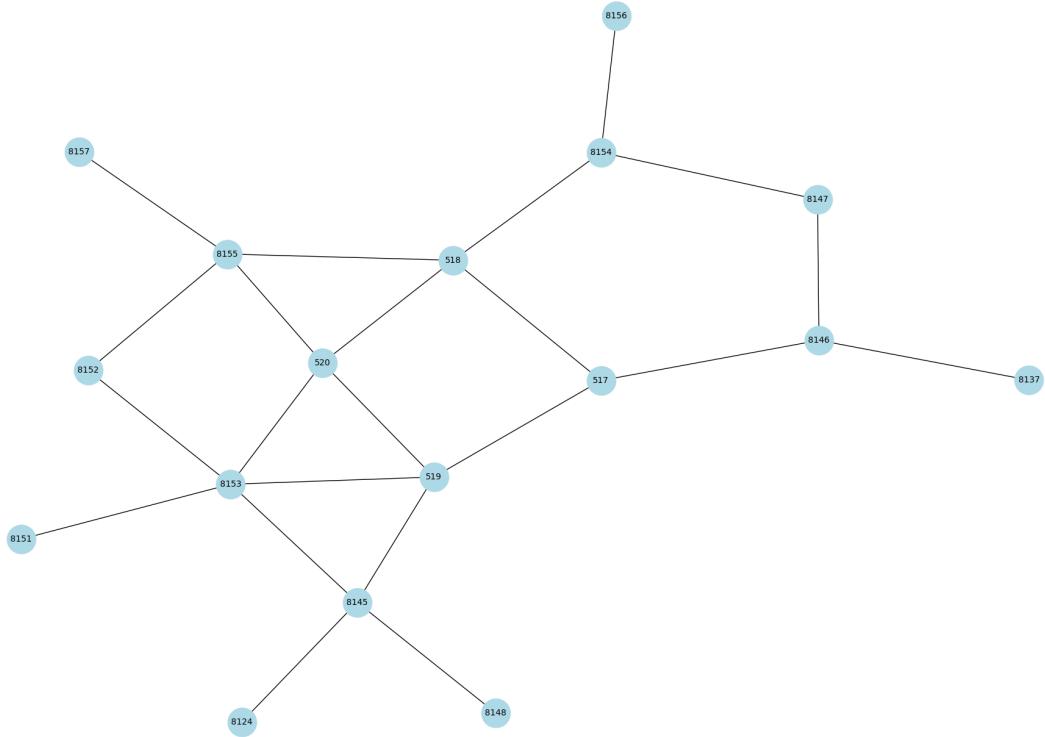
Size of the largest connected component: 19
Degree assortativity coefficient: -0.24768518518518623

	Node	Degree Centrality
2	516	0.278
0	514	0.222
12	1119	0.222
17	5883	0.222
18	5884	0.222
4	5894	0.222
1	515	0.167
11	1120	0.167
15	5874	0.111
9	1118	0.111
5	5890	0.056
6	5896	0.056
7	5893	0.056
8	5902	0.056
10	5854	0.056
13	5862	0.056
14	5864	0.056
16	5882	0.056
3	5892	0.056
	Node	Closeness Centrality
2	516	0.514
0	514	0.462
1	515	0.439
4	5894	0.400
18	5884	0.400
17	5883	0.391
12	1119	0.375
11	1120	0.353
3	5892	0.321
15	5874	0.321
9	1118	0.300
10	5854	0.290
13	5862	0.290
14	5864	0.290
7	5893	0.286
16	5882	0.286
5	5890	0.277
6	5896	0.277
8	5902	0.265
	Node	Betweenness Centrality
2	516	0.608
0	514	0.359
12	1119	0.261
17	5883	0.248
4	5894	0.216
1	515	0.190
18	5884	0.163
11	1120	0.150
9	1118	0.039
15	5874	0.020
7	5893	0.000
8	5902	0.000
6	5896	0.000
10	5854	0.000

5	5890	0.000
13	5862	0.000
14	5864	0.000
16	5882	0.000
3	5892	0.000
	Node	Katz Centrality
2	516	0.263
0	514	0.249
18	5884	0.249
4	5894	0.248
17	5883	0.247
12	1119	0.246
1	515	0.238
11	1120	0.235
15	5874	0.226
9	1118	0.225
3	5892	0.214
5	5890	0.214
6	5896	0.214
7	5893	0.214
10	5854	0.214
13	5862	0.214
14	5864	0.214
16	5882	0.214
8	5902	0.213



Graph 19 -----



----- Graph Stats -----

Nodes : 17 Edges : 17

Diameter : 6

Periphery : [8156, 8148, 8124]

Density of the graph: 0.16176470588235295

Average degree: 2.588235294117647

Size of the largest connected component: 17

Degree assortativity coefficient: -0.13304721030042904

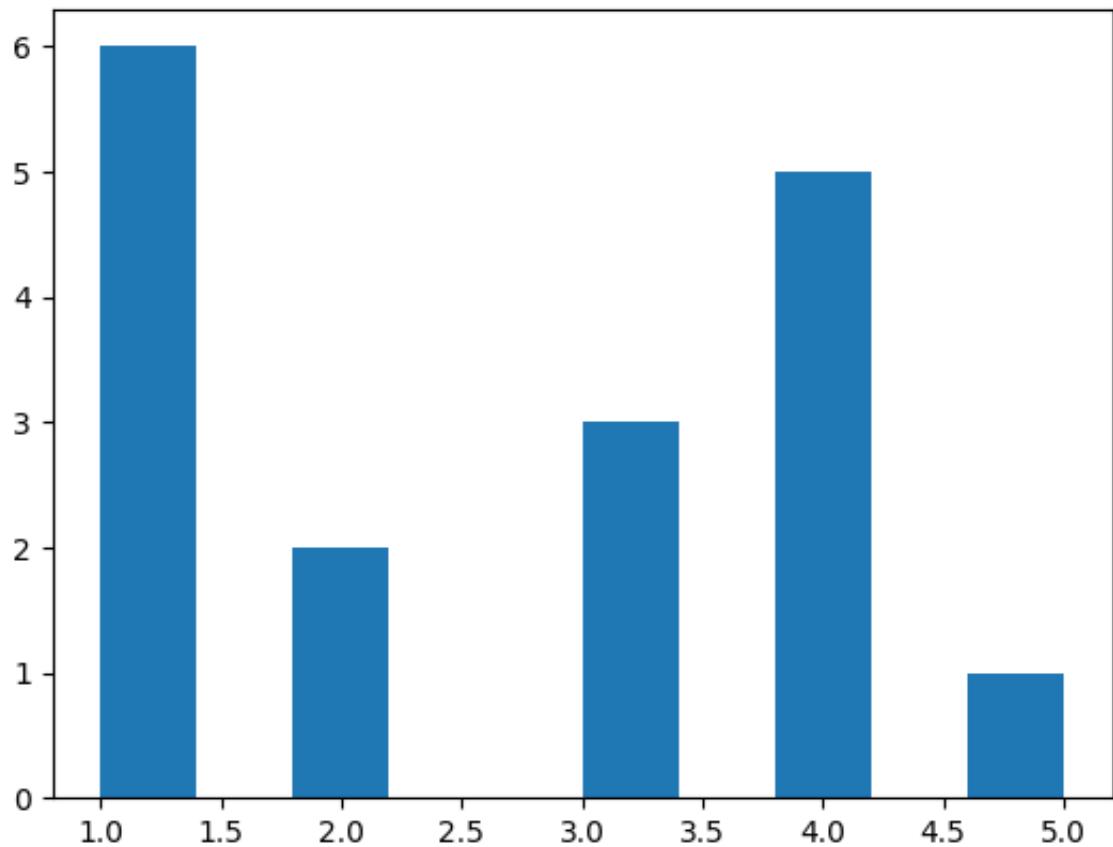
Node	Degree	Centrality
------	--------	------------

12	8153	0.312
2	519	0.250
3	520	0.250
14	8155	0.250
6	8145	0.250
1	518	0.250
0	517	0.188
13	8154	0.188
7	8146	0.188
11	8152	0.125
8	8147	0.125
10	8151	0.062
9	8148	0.062
5	8156	0.062
4	8137	0.062
15	8124	0.062
16	8157	0.062

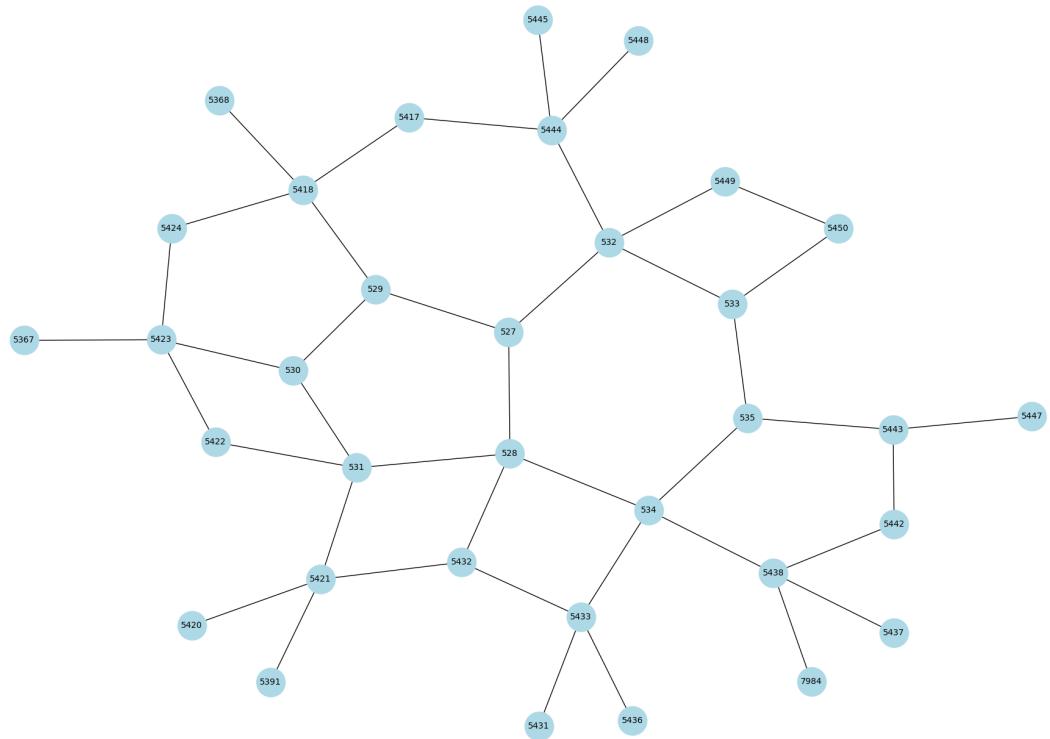
Node	Closeness	Centrality
------	-----------	------------

2	519	0.471
0	517	0.457
3	520	0.457
1	518	0.457
12	8153	0.444
14	8155	0.410

6	8145	0.381
11	8152	0.372
13	8154	0.364
7	8146	0.364
8	8147	0.320
10	8151	0.314
16	8157	0.296
9	8148	0.281
15	8124	0.281
5	8156	0.271
4	8137	0.271
	Node	Betweenness Centrality
1	518	0.300
0	517	0.263
2	519	0.262
12	8153	0.246
6	8145	0.242
3	520	0.188
14	8155	0.175
13	8154	0.175
7	8146	0.175
11	8152	0.033
8	8147	0.033
10	8151	0.000
9	8148	0.000
5	8156	0.000
4	8137	0.000
15	8124	0.000
16	8157	0.000
	Node	Katz Centrality
12	8153	0.271
3	520	0.262
2	519	0.261
1	518	0.260
14	8155	0.258
6	8145	0.258
0	517	0.248
13	8154	0.245
7	8146	0.245
11	8152	0.236
8	8147	0.234
10	8151	0.223
9	8148	0.222
5	8156	0.222
4	8137	0.222
15	8124	0.222
16	8157	0.222



----- Graph 20 -----



----- Graph Stats -----

Nodes : 34 Edges : 34

Diameter : 8

Periphery : [5424, 5447, 5367, 5368]

Density of the graph: 0.0748663101604278

Average degree: 2.4705882352941178

Size of the largest connected component: 34

Degree assortativity coefficient: -0.4439461883408069

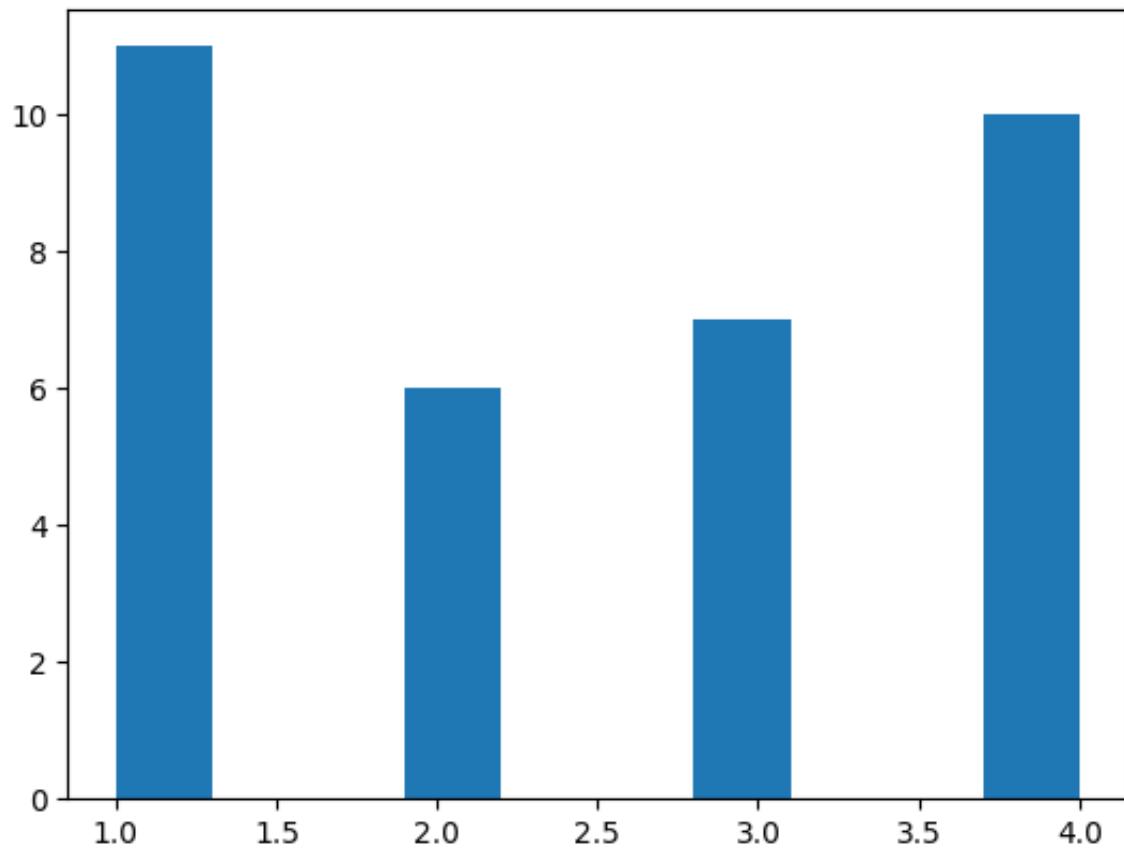
Node	Degree	Centrality
26	5444	0.121
23	5438	0.121
1	528	0.121
4	531	0.121
5	532	0.121
15	5423	0.121
7	534	0.121
13	5421	0.121
20	5433	0.121
11	5418	0.121
0	527	0.091
25	5443	0.091
19	5432	0.091
8	535	0.091
6	533	0.091
3	530	0.091
2	529	0.091
31	5450	0.061
24	5442	0.061
30	5449	0.061
17	5424	0.061
14	5422	0.061
10	5417	0.061
21	5436	0.030
22	5437	0.030
18	5431	0.030
16	7984	0.030
12	5420	0.030
27	5445	0.030
28	5447	0.030
29	5448	0.030
9	5391	0.030
32	5367	0.030
33	5368	0.030

Node Closeness Centrality

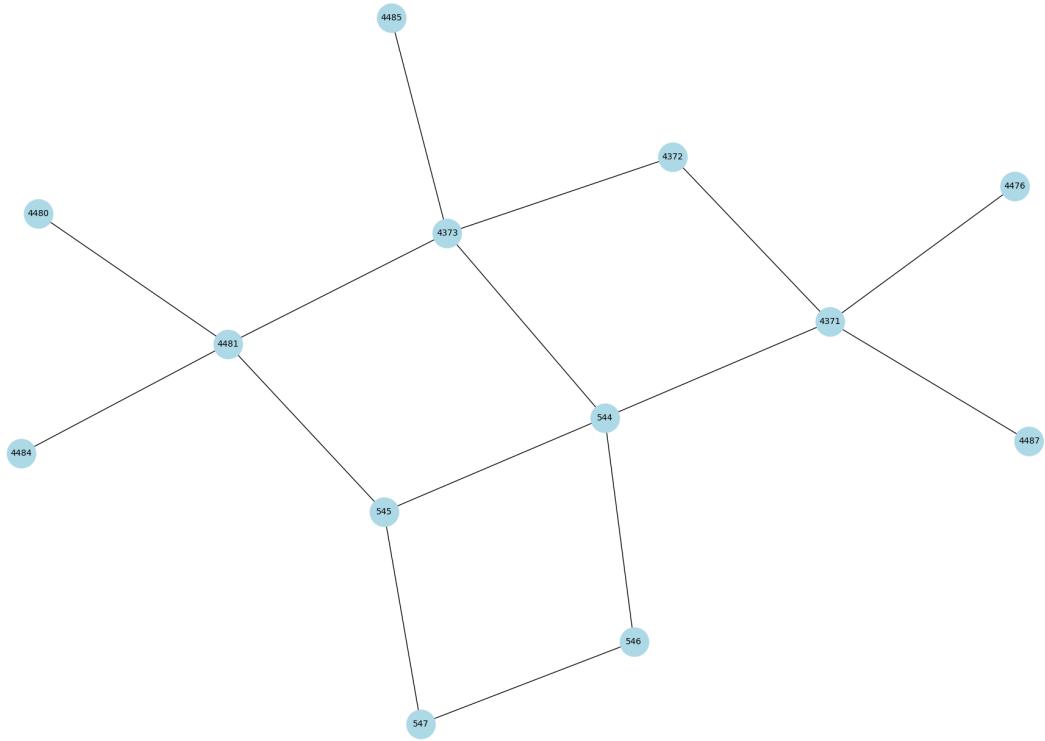
1	528	0.363
0	527	0.344
7	534	0.333
4	531	0.320
5	532	0.308
2	529	0.303
8	535	0.300
19	5432	0.297
3	530	0.292
6	533	0.287
20	5433	0.277
23	5438	0.268
13	5421	0.268
26	5444	0.264
11	5418	0.262
14	5422	0.262
15	5423	0.248
25	5443	0.244
30	5449	0.241

10	5417	0.241
24	5442	0.232
31	5450	0.228
17	5424	0.224
21	5436	0.219
18	5431	0.219
22	5437	0.213
16	7984	0.213
12	5420	0.213
9	5391	0.213
27	5445	0.210
29	5448	0.210
33	5368	0.209
32	5367	0.200
28	5447	0.198
	Node Betweenness Centrality	
1	528	0.364
7	534	0.347
5	532	0.254
0	527	0.252
4	531	0.219
8	535	0.191
26	5444	0.162
23	5438	0.155
20	5433	0.145
2	529	0.140
6	533	0.138
13	5421	0.136
11	5418	0.133
19	5432	0.122
3	530	0.099
15	5423	0.098
25	5443	0.078
10	5417	0.053
14	5422	0.044
17	5424	0.031
30	5449	0.016
24	5442	0.011
31	5450	0.009
18	5431	0.000
21	5436	0.000
22	5437	0.000
16	7984	0.000
12	5420	0.000
9	5391	0.000
27	5445	0.000
28	5447	0.000
29	5448	0.000
32	5367	0.000
33	5368	0.000
	Node Katz Centrality	
7	534	0.186
1	528	0.186
4	531	0.185
5	532	0.184
11	5418	0.183
15	5423	0.183

20	5433	0.183
13	5421	0.183
26	5444	0.183
23	5438	0.183
0	527	0.177
19	5432	0.177
3	530	0.177
6	533	0.176
2	529	0.176
8	535	0.176
25	5443	0.175
17	5424	0.168
14	5422	0.168
10	5417	0.168
24	5442	0.167
30	5449	0.167
31	5450	0.167
18	5431	0.159
16	7984	0.159
21	5436	0.159
22	5437	0.159
12	5420	0.159
9	5391	0.159
27	5445	0.159
29	5448	0.159
32	5367	0.159
33	5368	0.159
28	5447	0.158



----- Graph 21 -----



----- Graph Stats -----

Nodes : 13 Edges : 13

Diameter : 5

Periphery : [4480, 4487, 4484, 4476]

Density of the graph: 0.19230769230769232

Average degree: 2.3076923076923075

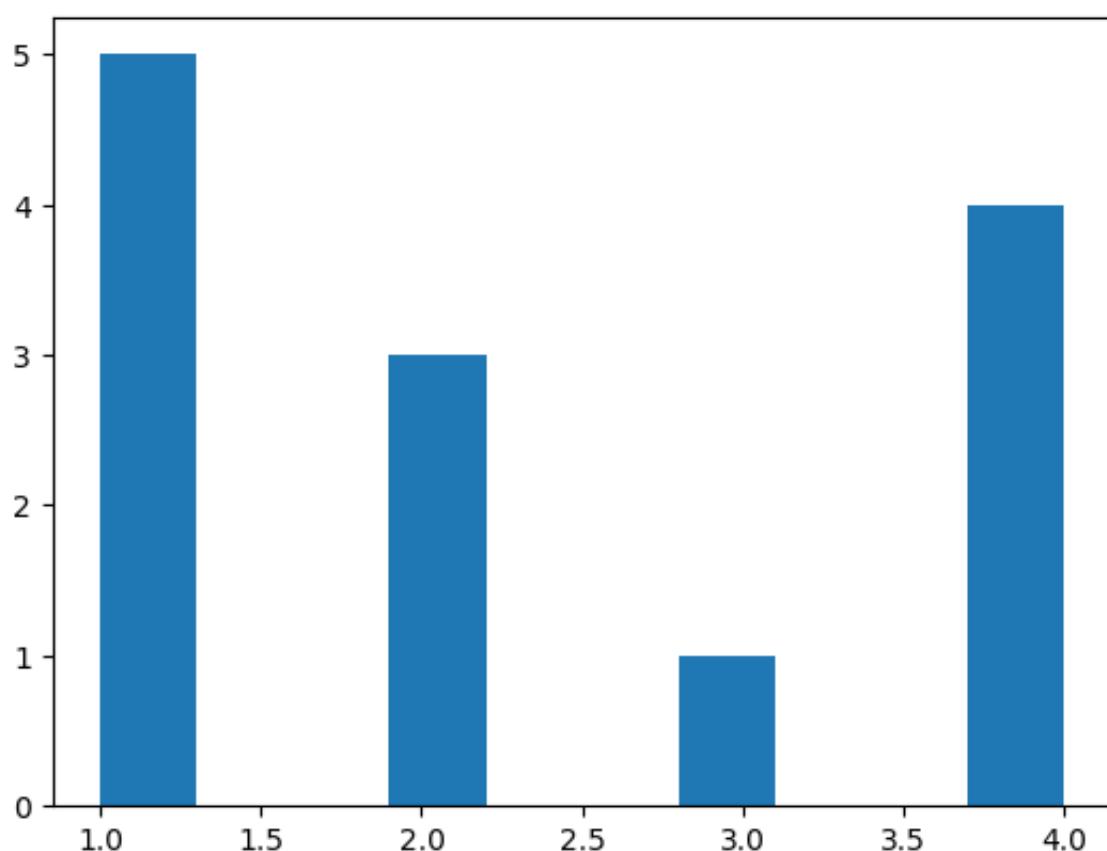
Size of the largest connected component: 13

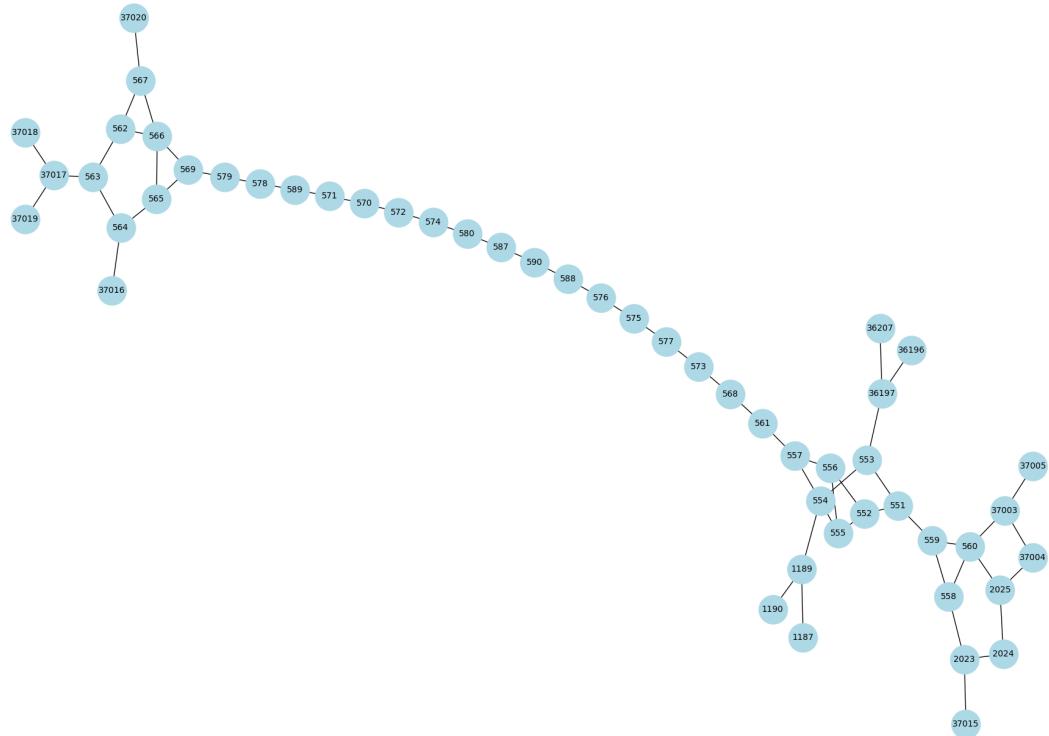
Degree assortativity coefficient: -0.4285714285714284

	Node	Degree	Centrality
0	544	3	0.333
4	4481	3	0.333
9	4371	3	0.333
11	4373	3	0.333
1	545	2	0.250
2	546	2	0.167
3	547	2	0.167
10	4372	2	0.167
5	4485	1	0.083
6	4480	1	0.083
7	4487	1	0.083
8	4484	1	0.083
12	4476	1	0.083

	Node	Closeness	Centrality
0	544	0.545	0.333
11	4373	0.522	0.333
1	545	0.480	0.250
4	4481	0.462	0.333
9	4371	0.444	0.333
10	4372	0.429	0.333
2	546	0.387	0.167
3	547	0.353	0.167
5	4485	0.353	0.083
6	4480	0.324	0.083

8	4484	0.324
7	4487	0.316
12	4476	0.316
Node Betweenness Centrality		
0	544	0.414
11	4373	0.375
4	4481	0.352
9	4371	0.344
1	545	0.204
10	4372	0.091
2	546	0.046
3	547	0.023
5	4485	0.000
6	4480	0.000
7	4487	0.000
8	4484	0.000
12	4476	0.000
Node Katz Centrality		
0	544	0.302
11	4373	0.300
4	4481	0.299
9	4371	0.298
1	545	0.287
10	4372	0.274
2	546	0.272
3	547	0.272
5	4485	0.259
6	4480	0.259
7	4487	0.259
8	4484	0.259
12	4476	0.259





----- Graph Stats -----

Nodes : 52 Edges : 52

Diameter : 30

Periphery : [37004, 37005, 37015, 37018, 37019, 2024]

Density of the graph: 0.04524886877828054

Average degree: 2.3076923076923075

Size of the largest connected component: 52

Degree assortativity coefficient: 0.19852602487333107

Node Degree Centrality

Node	Degree	centrality
27	566	0.078
21	560	0.078
15	554	0.078
0	37003	0.059
17	556	0.059
50	2025	0.059
48	2023	0.059
47	36197	0.059
30	569	0.059
28	567	0.059
25	564	0.059
24	563	0.059
23	562	0.059
20	559	0.059
19	558	0.059
18	557	0.059
26	565	0.059
16	555	0.059
10	1189	0.059
5	37017	0.059
14	553	0.059
12	551	0.059
13	552	0.059
49	2024	0.039

45	590	0.039
44	589	0.039
43	588	0.039
35	574	0.039
41	580	0.039
40	579	0.039
39	578	0.039
38	577	0.039
37	576	0.039
36	575	0.039
42	587	0.039
34	573	0.039
33	572	0.039
32	571	0.039
31	570	0.039
29	568	0.039
1	37004	0.039
22	561	0.039
6	37018	0.020
7	37019	0.020
8	37020	0.020
9	1187	0.020
46	36196	0.020
4	37016	0.020
3	37015	0.020
11	1190	0.020
2	37005	0.020
51	36207	0.020
	Node	Closeness Centrality
34	573	0.107
38	577	0.107
36	575	0.106
29	568	0.106
37	576	0.105
22	561	0.105
43	588	0.104
18	557	0.104
15	554	0.102
45	590	0.102
42	587	0.100
17	556	0.099
14	553	0.098
41	580	0.098
35	574	0.096
13	552	0.096
16	555	0.095
12	551	0.093
10	1189	0.093
33	572	0.093
47	36197	0.090
31	570	0.090
20	559	0.088
32	571	0.087
11	1190	0.085
9	1187	0.085
44	589	0.084
46	36196	0.083

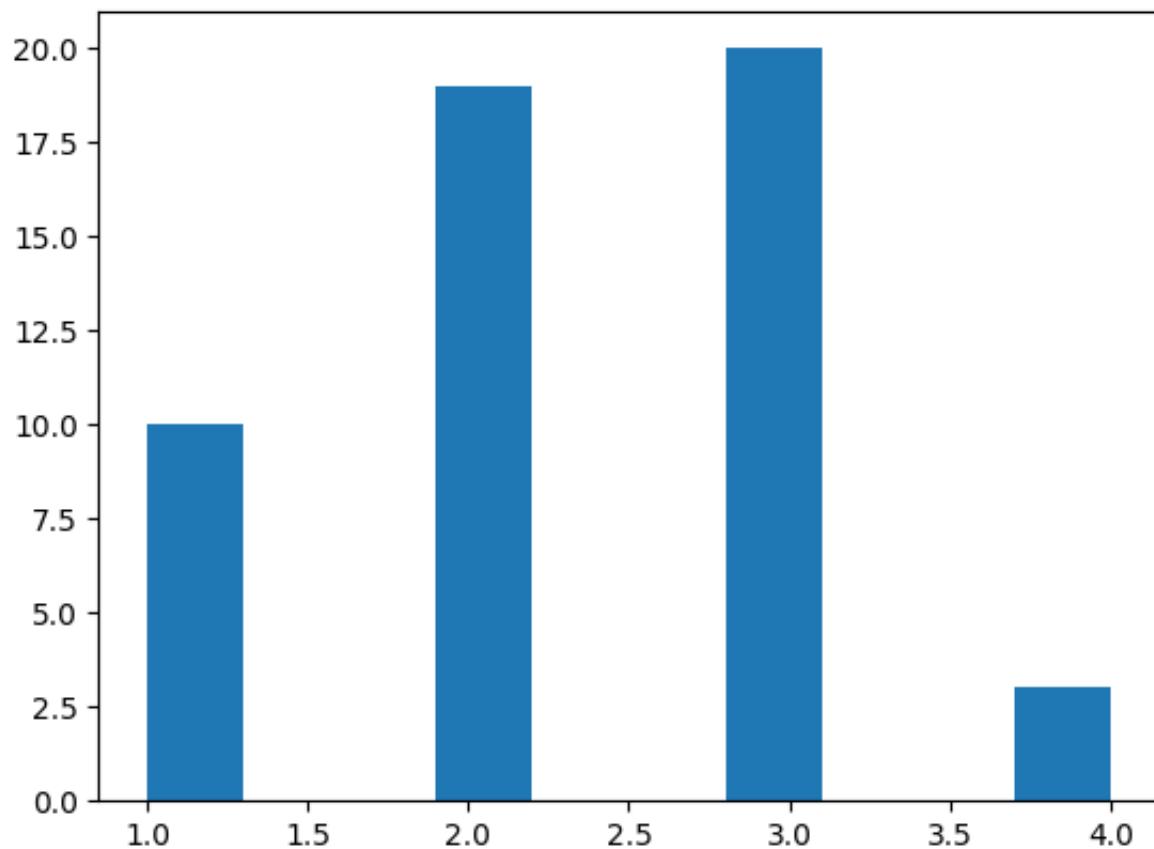
21	560	0.083
19	558	0.083
51	36207	0.083
39	578	0.080
48	2023	0.077
50	2025	0.077
40	579	0.077
0	37003	0.077
30	569	0.074
1	37004	0.072
3	37015	0.072
49	2024	0.072
2	37005	0.072
27	566	0.071
26	565	0.071
28	567	0.067
25	564	0.067
23	562	0.067
24	563	0.064
8	37020	0.063
4	37016	0.063
5	37017	0.060
7	37019	0.057
6	37018	0.057
	Node	Betweenness Centrality
34	573	0.510
38	577	0.510
36	575	0.508
29	568	0.508
37	576	0.505
22	561	0.505
18	557	0.503
43	588	0.500
45	590	0.494
42	587	0.486
41	580	0.477
35	574	0.466
33	572	0.453
31	570	0.439
32	571	0.424
44	589	0.406
39	578	0.387
40	579	0.367
15	554	0.353
30	569	0.345
12	551	0.326
20	559	0.296
14	553	0.277
27	566	0.165
17	556	0.165
21	560	0.160
13	552	0.148
26	565	0.132
24	563	0.116
25	564	0.107
19	558	0.089
5	37017	0.078

47	36197	0.078
10	1189	0.078
23	562	0.075
48	2023	0.057
0	37003	0.057
28	567	0.039
50	2025	0.039
16	555	0.006
49	2024	0.003
1	37004	0.002
11	1190	0.000
9	1187	0.000
8	37020	0.000
7	37019	0.000
6	37018	0.000
4	37016	0.000
46	36196	0.000
3	37015	0.000
2	37005	0.000
51	36207	0.000

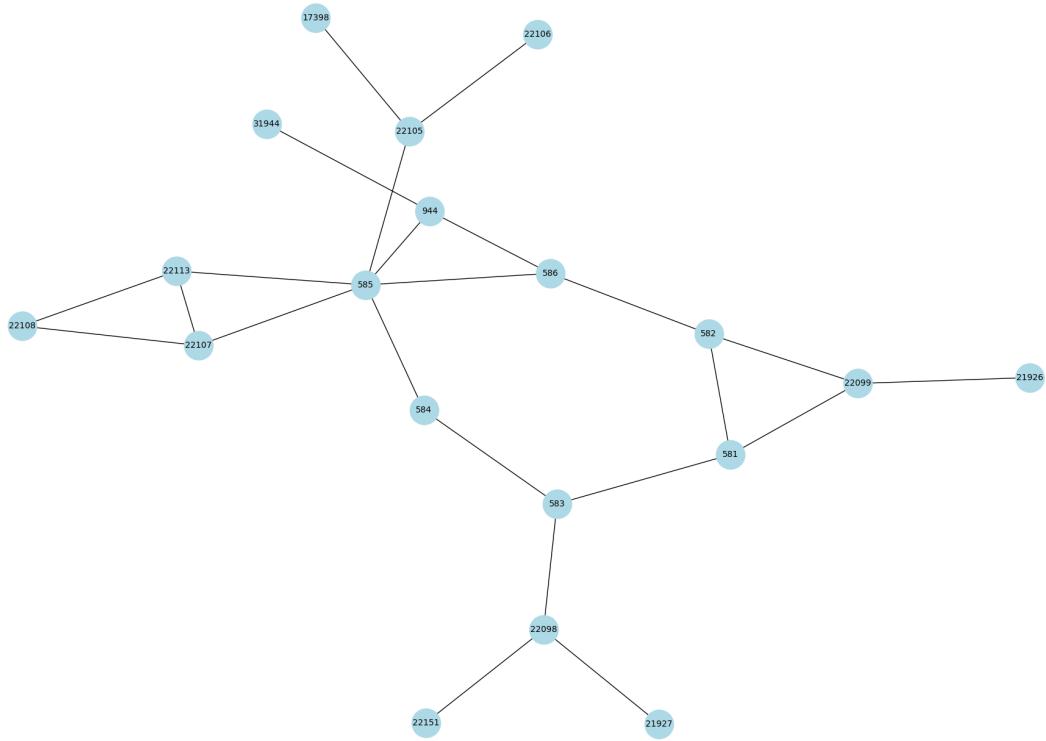
Node Katz Centrality

21	560	0.151
15	554	0.151
27	566	0.151
26	565	0.144
17	556	0.144
16	555	0.144
14	553	0.144
13	552	0.144
12	551	0.144
20	559	0.144
23	562	0.144
19	558	0.144
24	563	0.144
28	567	0.144
30	569	0.144
18	557	0.144
25	564	0.143
48	2023	0.143
50	2025	0.143
0	37003	0.143
10	1189	0.143
47	36197	0.142
5	37017	0.142
49	2024	0.137
1	37004	0.137
36	575	0.136
35	574	0.136
43	588	0.136
42	587	0.136
41	580	0.136
40	579	0.136
39	578	0.136
38	577	0.136
37	576	0.136
32	571	0.136
34	573	0.136

33	572	0.136
45	590	0.136
31	570	0.136
29	568	0.136
22	561	0.136
44	589	0.136
46	36196	0.129
3	37015	0.129
2	37005	0.129
11	1190	0.129
4	37016	0.129
6	37018	0.129
7	37019	0.129
8	37020	0.129
9	1187	0.129
51	36207	0.129



----- Graph 23 -----



----- Graph Stats -----

Nodes : 19 Edges : 19

Diameter : 6

Periphery : [22151, 21926, 21927, 31944, 22106, 22108, 17398]

Density of the graph: 0.13450292397660818

Average degree: 2.4210526315789473

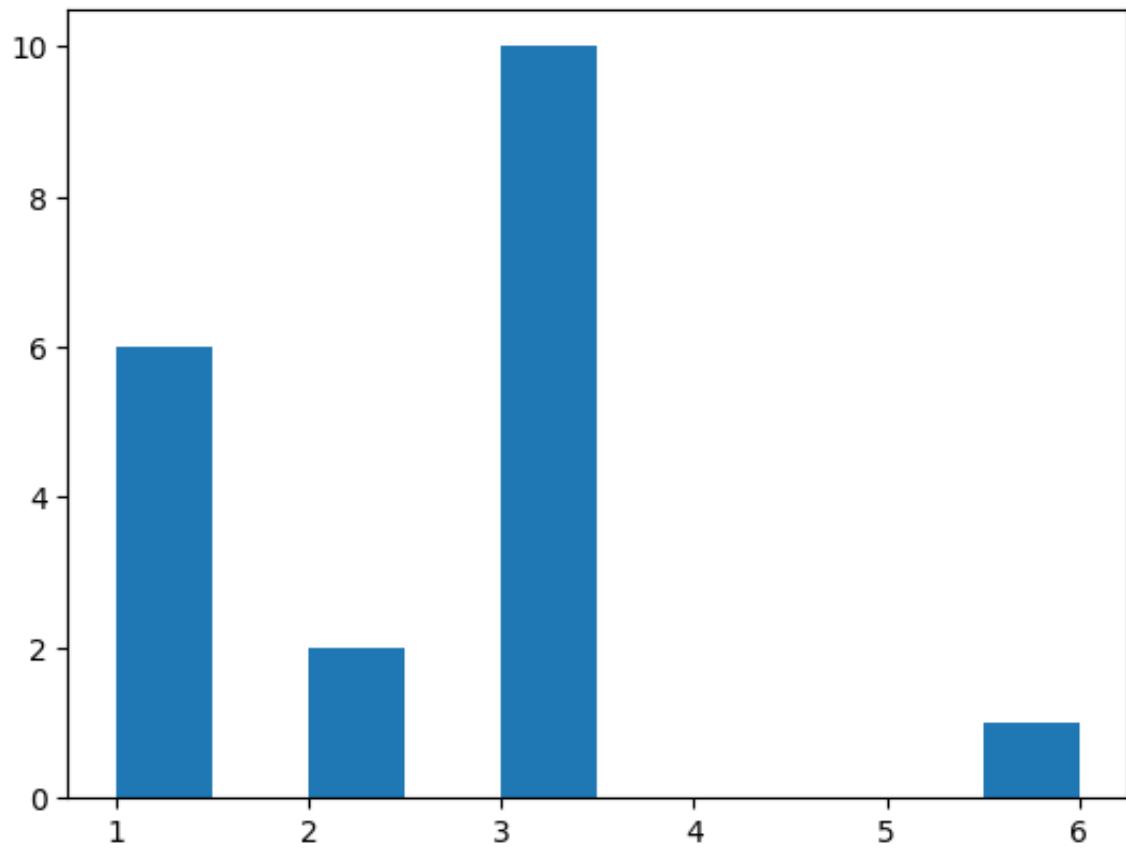
Size of the largest connected component: 19

Degree assortativity coefficient: -0.07430997876857752

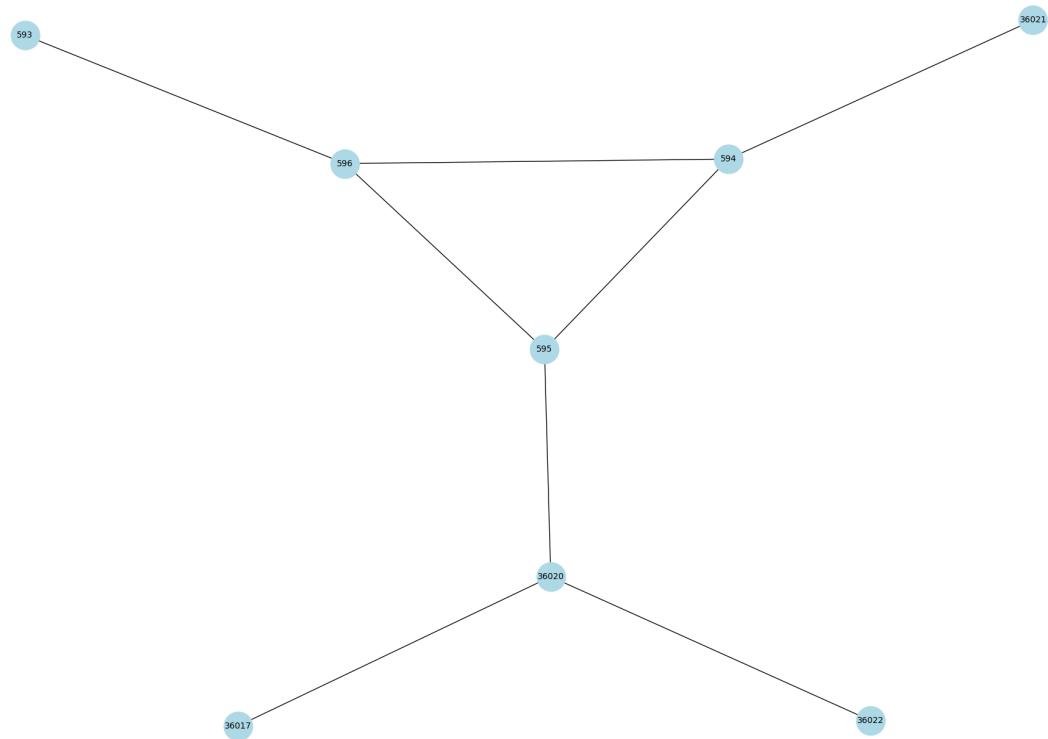
	Node	Degree	Centrality
8	585	3	0.333
9	586	3	0.167
17	22113	3	0.167
3	944	3	0.167
4	581	3	0.167
5	582	3	0.167
6	583	3	0.167
15	22107	3	0.167
11	22098	3	0.167
12	22099	3	0.167
13	22105	3	0.167
7	584	2	0.111
16	22108	2	0.111
14	22106	1	0.056
0	22151	1	0.056
10	31944	1	0.056
1	21926	1	0.056
2	21927	1	0.056
18	17398	1	0.056

	Node	Closeness	Centrality
8	585	0.462	
7	584	0.409	
9	586	0.391	
6	583	0.383	

3	944	0.367
5	582	0.367
13	22105	0.346
15	22107	0.340
17	22113	0.340
4	581	0.333
12	22099	0.310
11	22098	0.300
10	31944	0.273
16	22108	0.261
18	17398	0.261
14	22106	0.261
1	21926	0.240
2	21927	0.234
0	22151	0.234
	Node	Betweenness Centrality
8	585	0.618
6	583	0.340
7	584	0.271
9	586	0.216
11	22098	0.216
13	22105	0.216
5	582	0.186
3	944	0.111
12	22099	0.111
4	581	0.108
17	22113	0.052
15	22107	0.052
14	22106	0.000
16	22108	0.000
0	22151	0.000
10	31944	0.000
1	21926	0.000
2	21927	0.000
18	17398	0.000
	Node	Katz Centrality
8	585	0.271
9	586	0.237
17	22113	0.237
15	22107	0.237
3	944	0.236
4	581	0.236
5	582	0.236
6	583	0.235
12	22099	0.235
13	22105	0.235
11	22098	0.233
7	584	0.226
16	22108	0.224
14	22106	0.212
0	22151	0.212
10	31944	0.212
1	21926	0.212
2	21927	0.212
18	17398	0.212



Graph 24



----- Graph Stats -----

Nodes : 8 Edges : 8

Diameter : 4

Periphery : [593, 36021, 36017, 36022]

Density of the graph: 0.2857142857142857

Average degree: 2.0

Size of the largest connected component: 8

Degree assortativity coefficient: -0.3333333333333333

Node Degree Centrality

1	594	0.429
2	595	0.429
3	596	0.429
5	36020	0.429
0	593	0.143
4	36021	0.143
6	36017	0.143
7	36022	0.143

Node Closeness Centrality

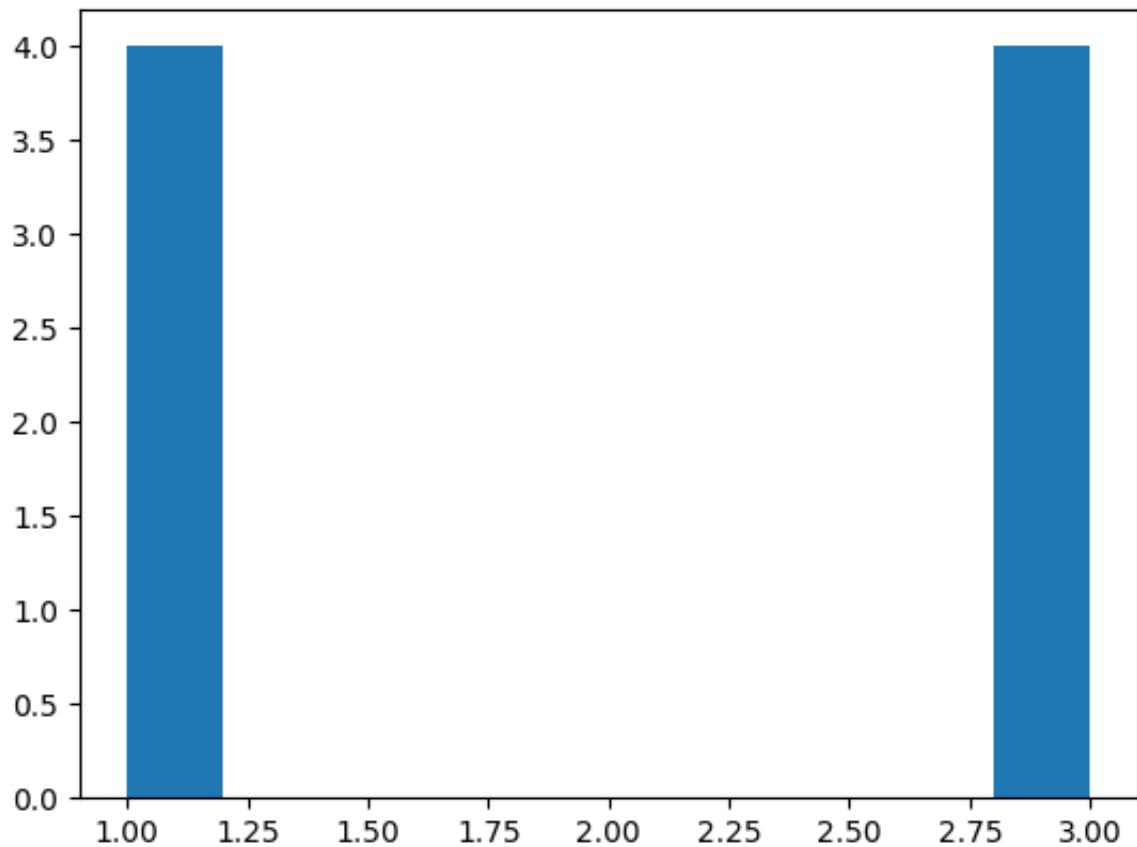
2	595	0.636
1	594	0.538
3	596	0.538
5	36020	0.538
0	593	0.368
4	36021	0.368
6	36017	0.368
7	36022	0.368

Node Betweenness Centrality

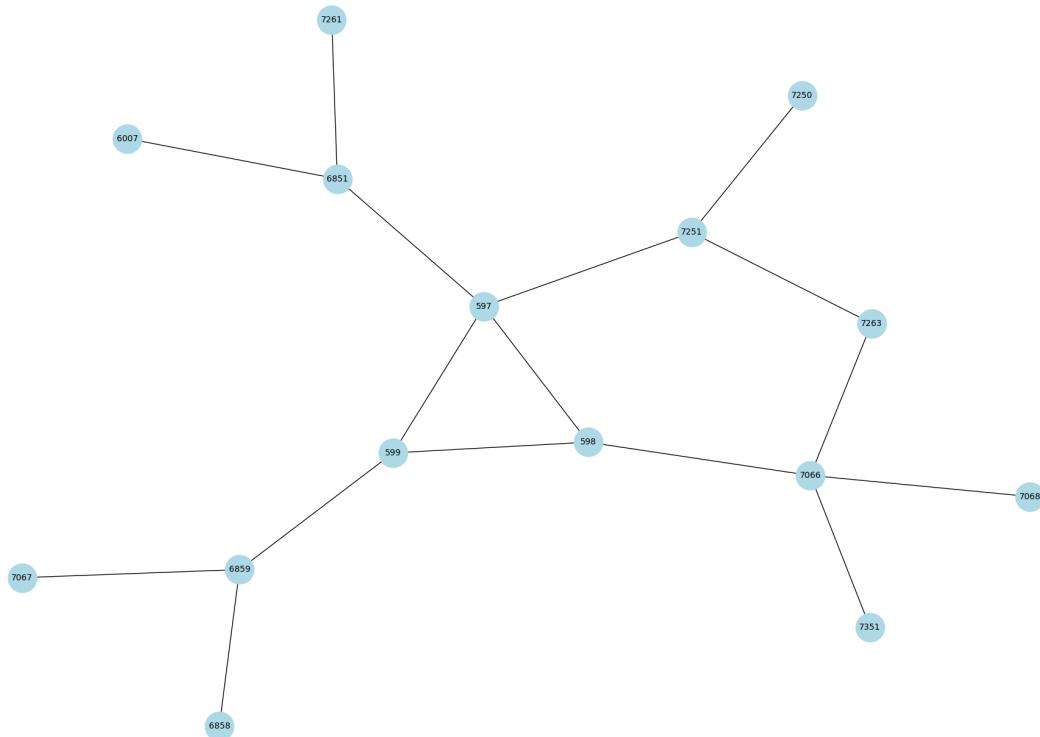
2	595	0.571
5	36020	0.524
1	594	0.286
3	596	0.286
0	593	0.000
4	36021	0.000
6	36017	0.000
7	36022	0.000

Node Katz Centrality

2	595	0.372
1	594	0.371
3	596	0.371
5	36020	0.369
0	593	0.335
4	36021	0.335
6	36017	0.335
7	36022	0.335



----- Graph 25 -----



----- Graph Stats -----

Nodes : 15 Edges : 15

Diameter : 5

Periphery : [6858, 7250, 6007, 7351, 7067, 7068, 7261, 7263]

Density of the graph: 0.1523809523809524

Average degree: 2.133333333333333

Size of the largest connected component: 15

Degree assortativity coefficient: -0.3333333333333333

Node Degree Centrality

6	597	0.286
10	7066	0.286
0	6851	0.214
1	599	0.214
3	6859	0.214
5	7251	0.214
7	598	0.214
14	7263	0.143
2	6858	0.071
4	7250	0.071
8	6007	0.071
9	7351	0.071
11	7067	0.071
12	7068	0.071
13	7261	0.071

Node Closeness Centrality

6	597	0.500
7	598	0.467
1	599	0.452
5	7251	0.412
10	7066	0.400
0	6851	0.378
3	6859	0.350
14	7263	0.350
4	7250	0.298
9	7351	0.292
12	7068	0.292
8	6007	0.280
13	7261	0.280
2	6858	0.264
11	7067	0.264

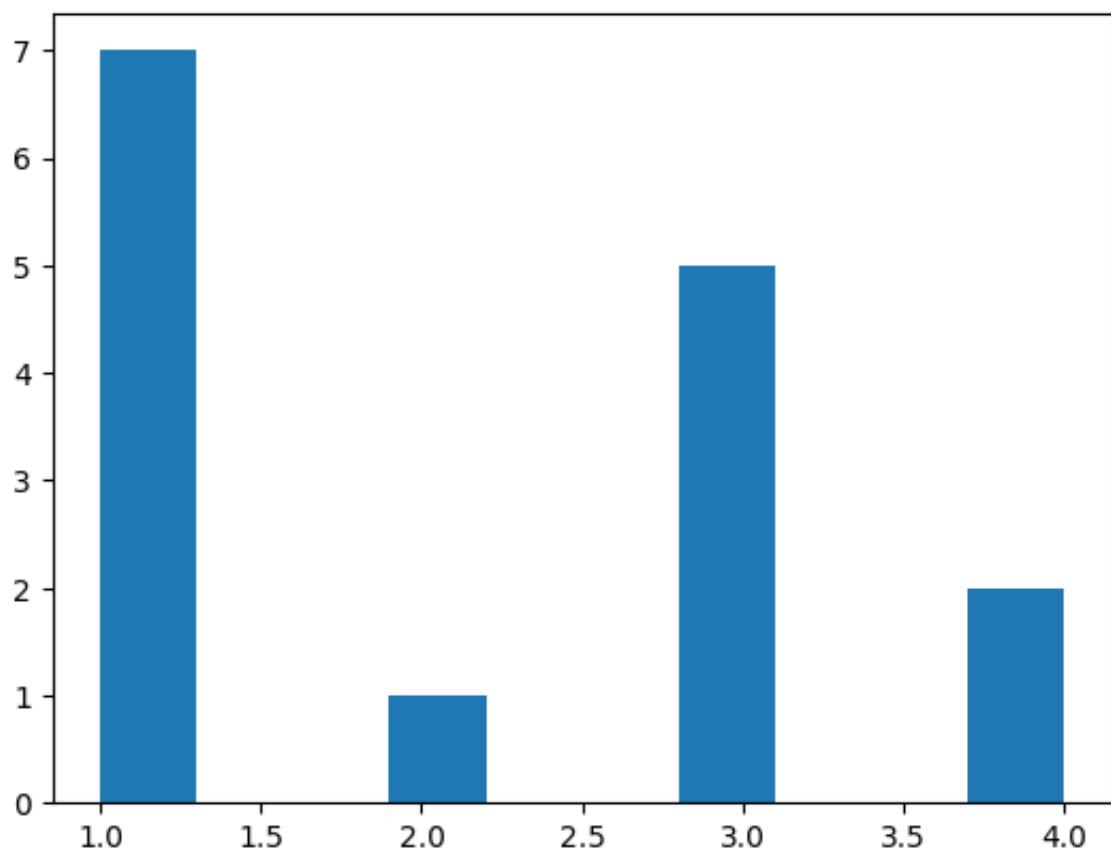
Node Betweenness Centrality

6	597	0.495
1	599	0.363
10	7066	0.308
7	598	0.286
0	6851	0.275
3	6859	0.275
5	7251	0.209
14	7263	0.066
2	6858	0.000
4	7250	0.000
8	6007	0.000
9	7351	0.000
11	7067	0.000
12	7068	0.000
13	7261	0.000

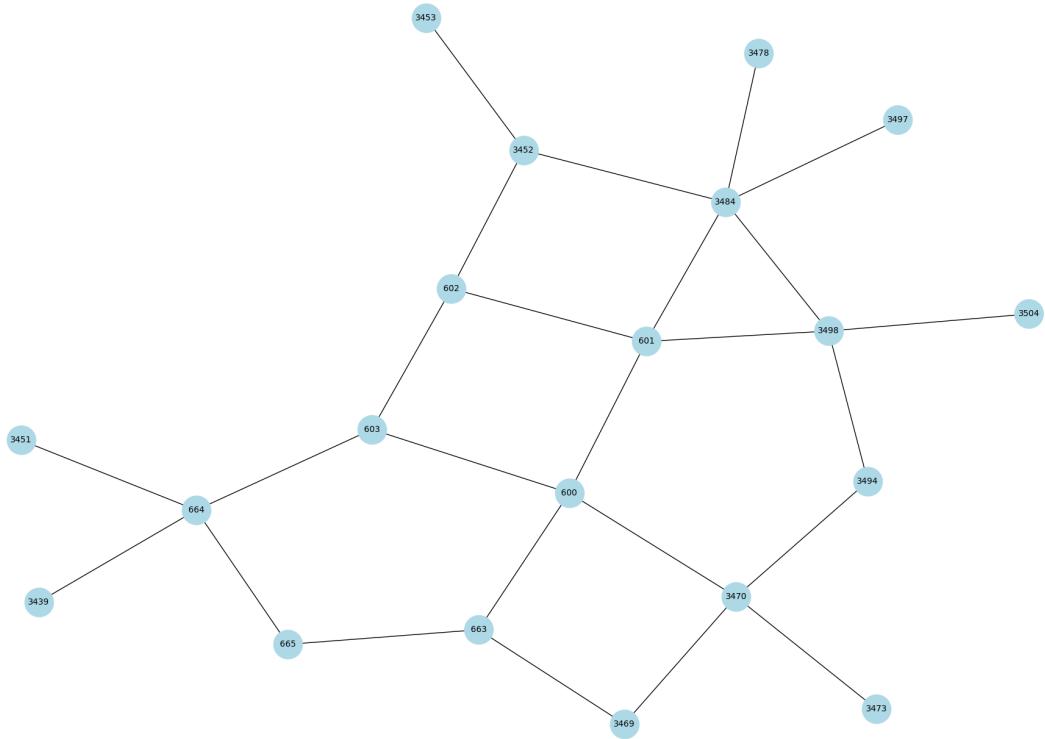
Node Katz Centrality

6	597	0.283
10	7066	0.280
7	598	0.271
1	599	0.270
5	7251	0.269
0	6851	0.268

3	6859	0.267
14	7263	0.257
2	6858	0.243
4	7250	0.243
8	6007	0.243
9	7351	0.243
11	7067	0.243
12	7068	0.243
13	7261	0.243



----- Graph 26 -----



----- Graph Stats -----

Nodes : 20 Edges : 20

Diameter : 6

Periphery : [3469, 3473, 3478, 3497, 3504, 3439, 3451, 3453]

Density of the graph: 0.13157894736842105

Average degree: 2.5

Size of the largest connected component: 20

Degree assortativity coefficient: -0.388888888888894

Node Degree Centrality

7	3484	0.263
10	3498	0.211
1	3470	0.211
5	664	0.211
13	601	0.211
12	600	0.211
18	3452	0.158
15	603	0.158
4	663	0.158
14	602	0.158
0	3469	0.105
8	3494	0.105
6	665	0.105
11	3504	0.053
9	3497	0.053
3	3478	0.053
16	3439	0.053
17	3451	0.053
2	3473	0.053
19	3453	0.053

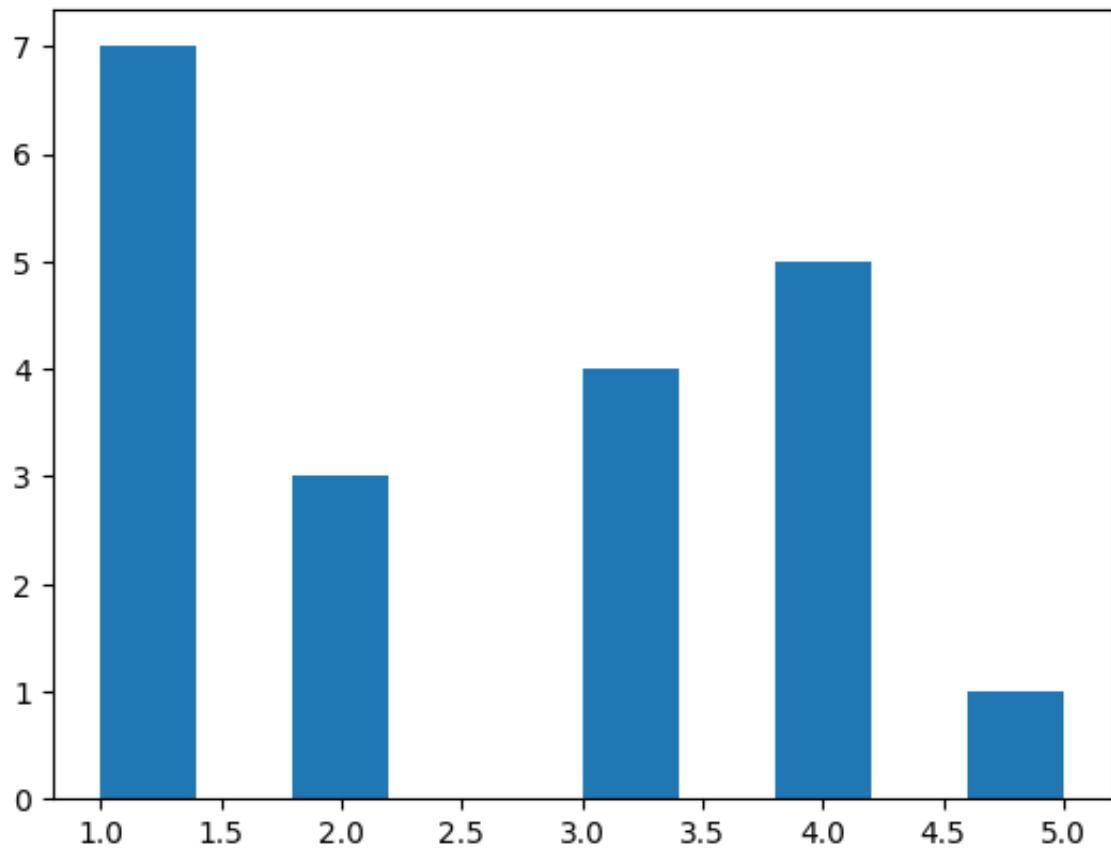
Node Closeness Centrality

12	600	0.452
13	601	0.442
15	603	0.404

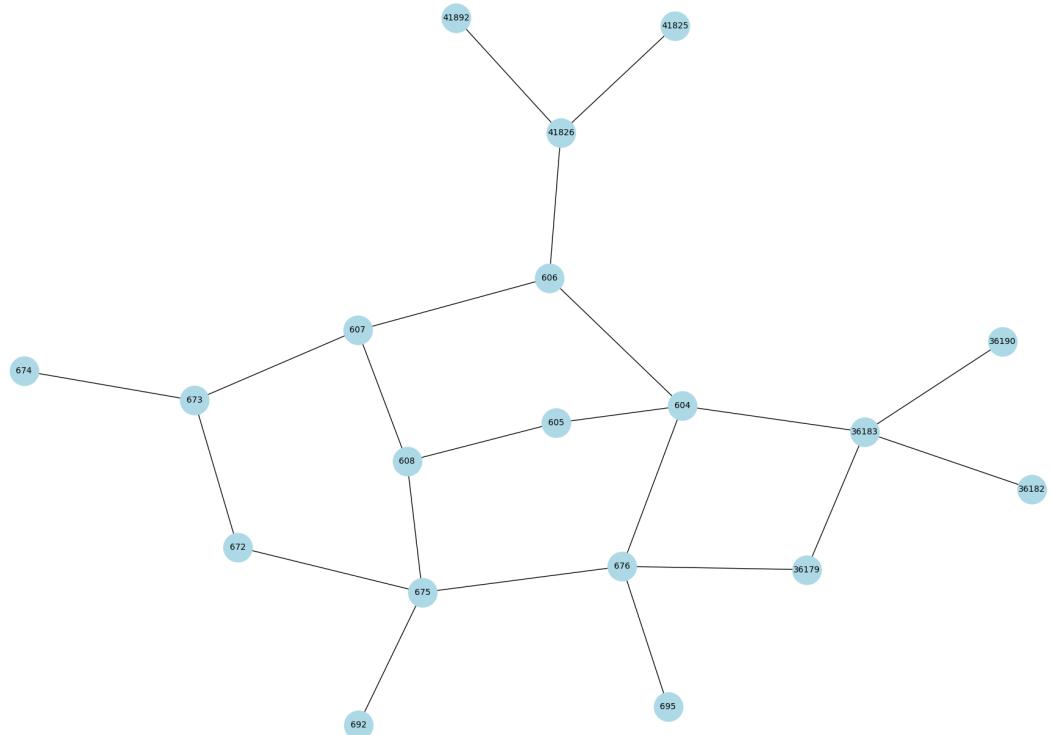
14	602	0.396
10	3498	0.388
7	3484	0.380
1	3470	0.365
4	663	0.358
8	3494	0.352
18	3452	0.345
5	664	0.333
6	665	0.311
0	3469	0.302
11	3504	0.284
9	3497	0.279
3	3478	0.279
2	3473	0.271
19	3453	0.260
16	3439	0.253
17	3451	0.253
Node Betweenness Centrality		
12	600	0.338
13	601	0.285
15	603	0.277
7	3484	0.270
5	664	0.228
1	3470	0.194
14	602	0.180
10	3498	0.177
18	3452	0.137
4	663	0.104
8	3494	0.066
6	665	0.035
0	3469	0.018
11	3504	0.000
9	3497	0.000
3	3478	0.000
16	3439	0.000
17	3451	0.000
2	3473	0.000
19	3453	0.000
Node Katz Centrality		
7	3484	0.250
13	601	0.242
12	600	0.241
10	3498	0.240
1	3470	0.238
5	664	0.237
15	603	0.230
18	3452	0.229
14	602	0.229
4	663	0.228
0	3469	0.218
8	3494	0.218
6	665	0.218
9	3497	0.207
3	3478	0.207
11	3504	0.206
16	3439	0.206
17	3451	0.206

2 3473
19 3453

0.206
0.206



----- Graph 27 -----



----- Graph Stats -----

Nodes : 19 Edges : 19

Diameter : 6

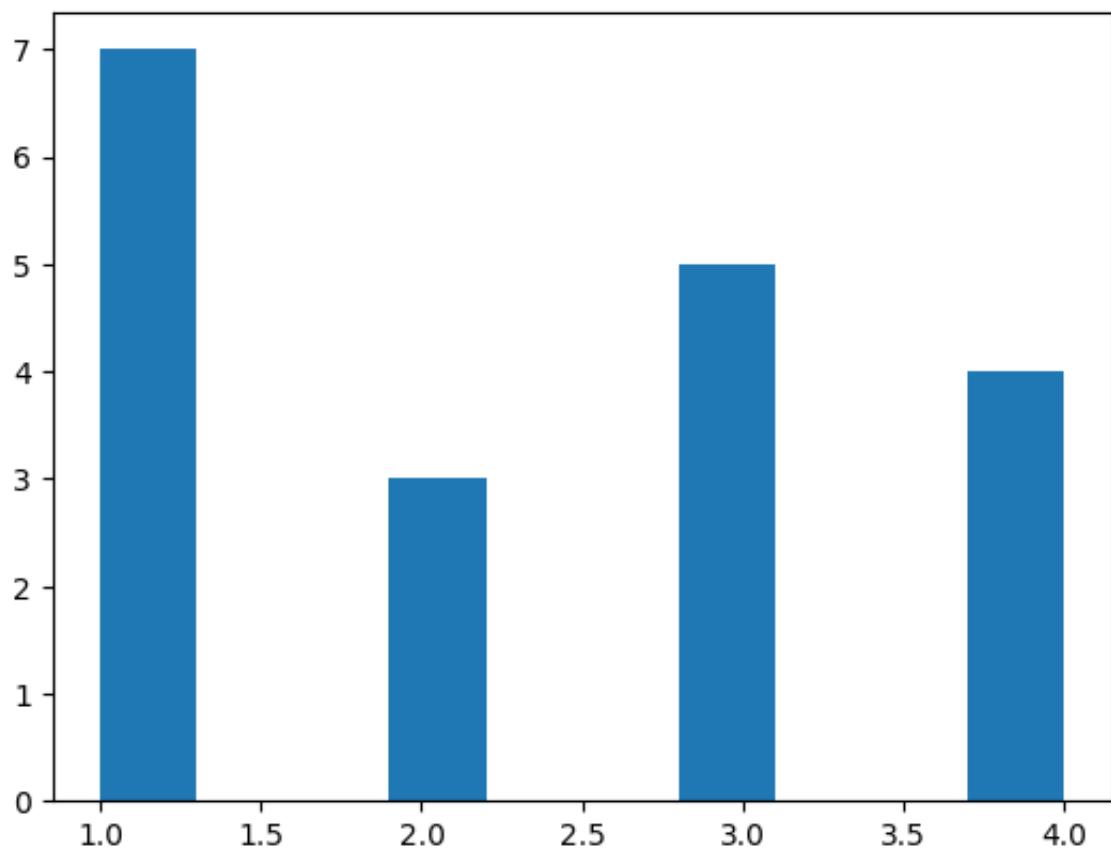
Periphery : [674, 41892, 692, 36182, 36190, 41825]

Density of the graph: 0.1286549707602339
 Average degree: 2.3157894736842106
 Size of the largest connected component: 19
 Degree assortativity coefficient: -0.3699633699633703

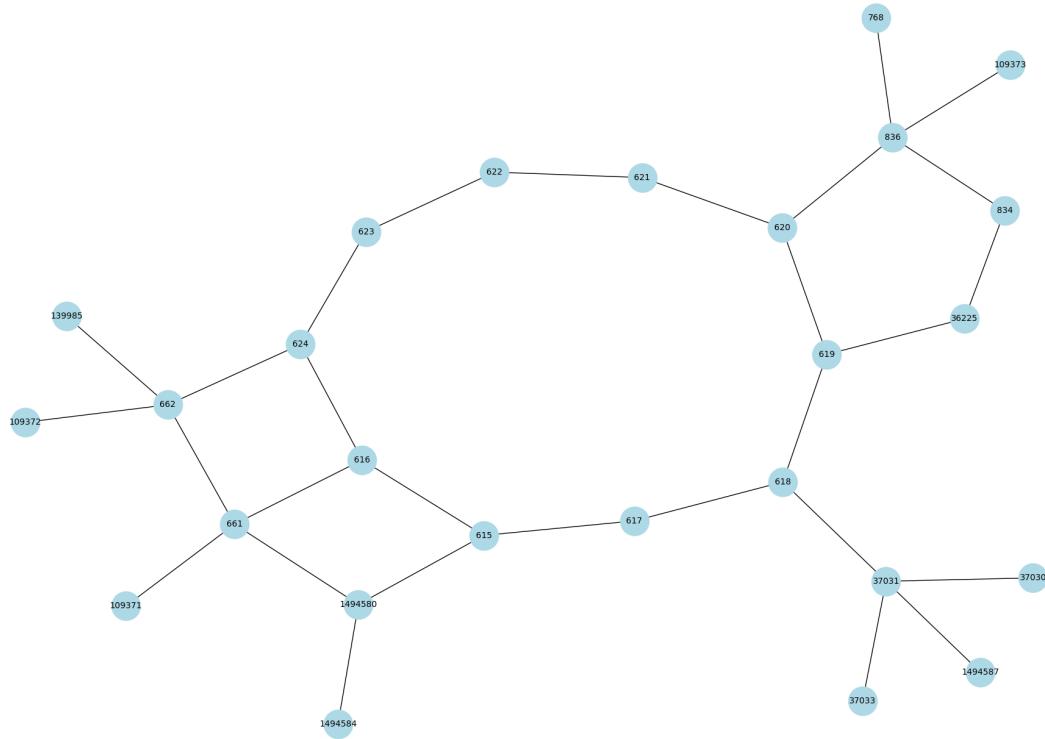
	Node	Degree Centrality
10	36183	0.222
3	675	0.222
4	676	0.222
11	604	0.222
18	607	0.167
17	41826	0.167
15	608	0.167
14	606	0.167
1	673	0.167
12	605	0.111
0	672	0.111
8	36179	0.111
7	695	0.056
13	36190	0.056
6	692	0.056
5	41892	0.056
16	41825	0.056
2	674	0.056
9	36182	0.056
	Node	Closeness Centrality
11	604	0.462
14	606	0.429
4	676	0.419
18	607	0.391
15	608	0.391
3	675	0.383
12	605	0.375
10	36183	0.360
8	36179	0.333
1	673	0.333
17	41826	0.327
0	672	0.327
7	695	0.300
6	692	0.281
13	36190	0.269
9	36182	0.269
2	674	0.254
5	41892	0.250
16	41825	0.250
	Node	Betweenness Centrality
11	604	0.387
14	606	0.383
4	676	0.279
3	675	0.237
10	36183	0.237
17	41826	0.216
18	607	0.209
1	673	0.144
15	608	0.087
0	672	0.065
8	36179	0.049
12	605	0.026

7	695	0.000
13	36190	0.000
6	692	0.000
5	41892	0.000
16	41825	0.000
2	674	0.000
9	36182	0.000

	Node	Katz Centrality
11	604	0.250
4	676	0.249
3	675	0.248
10	36183	0.247
14	606	0.238
18	607	0.237
15	608	0.237
1	673	0.236
17	41826	0.235
12	605	0.226
0	672	0.226
8	36179	0.226
7	695	0.214
13	36190	0.214
6	692	0.214
5	41892	0.214
16	41825	0.214
2	674	0.214
9	36182	0.214



Graph 28



----- Graph Stats -----

Nodes : 26 Edges : 26

Diameter : 9

Periphery : [768, 109371, 109373]

Density of the graph: 0.08923076923076922

Average degree: 2.230769230769231

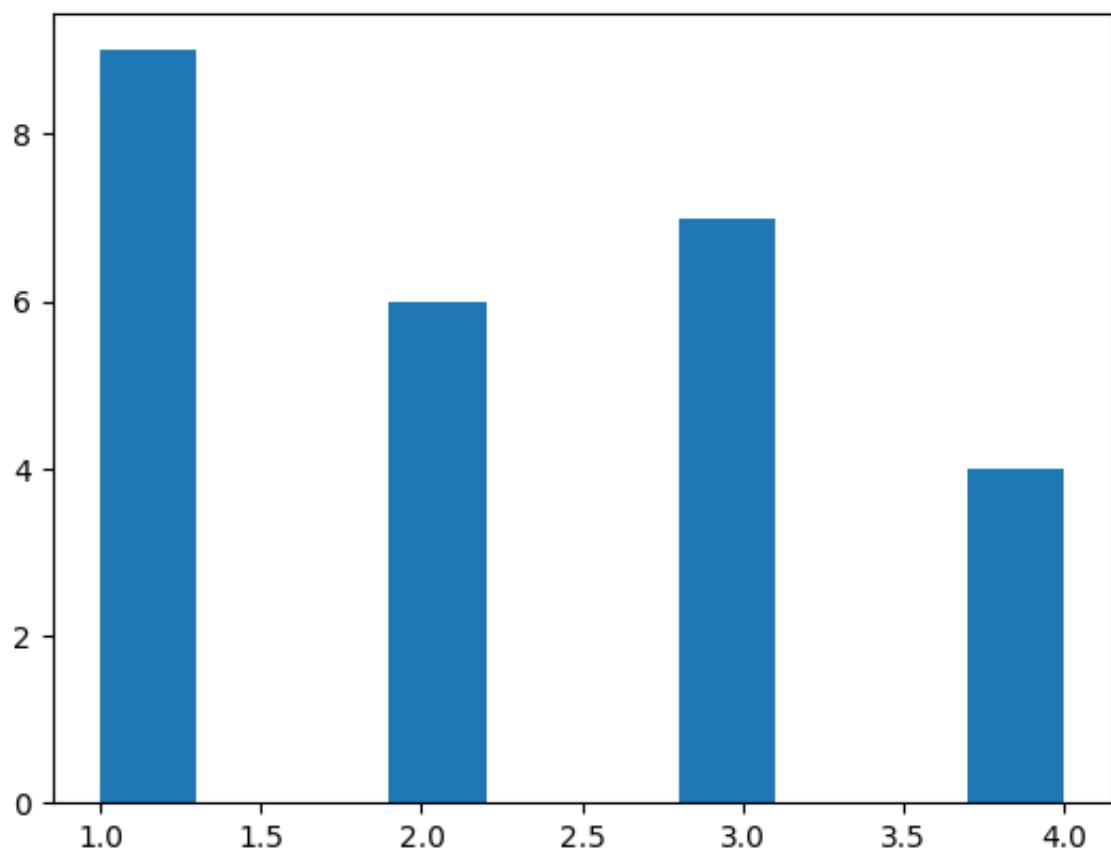
Size of the largest connected component: 26

Degree assortativity coefficient: -0.4846416382252563

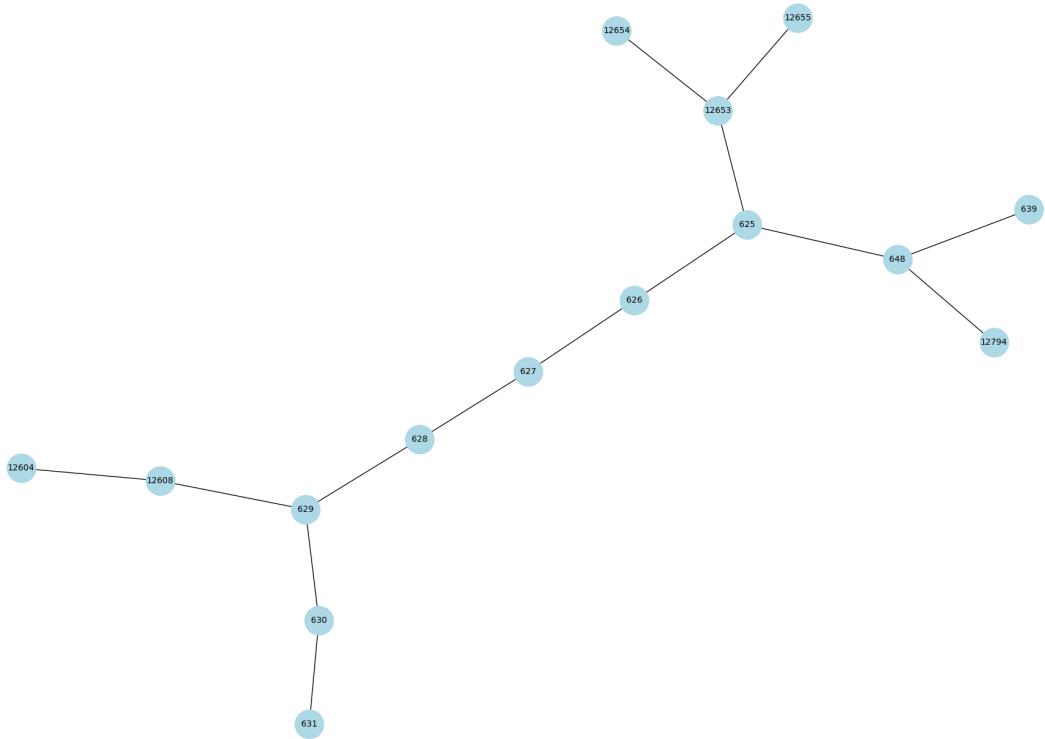
	Node	Degree	Centrality
2	661	2	0.16
3	662	2	0.16
5	37031	2	0.16
14	836	2	0.16
25	624	2	0.12
16	615	2	0.12
7	1494580	2	0.12
21	620	2	0.12
20	619	2	0.12
19	618	2	0.12
17	616	2	0.12
24	623	2	0.08
23	622	2	0.08
22	621	2	0.08
18	617	2	0.08
13	834	2	0.08
1	36225	2	0.08
15	139985	2	0.04
12	109373	2	0.04
11	109372	2	0.04
10	109371	2	0.04
9	1494587	2	0.04
8	1494584	2	0.04
6	37033	2	0.04

4	37030	0.04
0	768	0.04
Node Closeness Centrality		
19	618	0.309
18	617	0.301
16	615	0.294
20	619	0.287
21	620	0.278
17	616	0.275
25	624	0.266
22	621	0.260
7	1494580	0.258
23	622	0.255
5	37031	0.253
24	623	0.250
2	661	0.243
3	662	0.236
1	36225	0.236
14	836	0.234
13	834	0.216
8	1494584	0.207
9	1494587	0.203
6	37033	0.203
4	37030	0.203
10	109371	0.197
15	139985	0.192
11	109372	0.192
12	109373	0.191
0	768	0.191
Node Betweenness Centrality		
19	618	0.450
16	615	0.322
18	617	0.317
21	620	0.302
20	619	0.297
5	37031	0.230
25	624	0.208
3	662	0.185
14	836	0.183
2	661	0.182
17	616	0.182
22	621	0.168
24	623	0.160
23	622	0.160
7	1494580	0.148
1	36225	0.043
13	834	0.010
15	139985	0.000
12	109373	0.000
11	109372	0.000
10	109371	0.000
9	1494587	0.000
8	1494584	0.000
6	37033	0.000
4	37030	0.000
0	768	0.000
Node Katz Centrality		

2	661	0.214
3	662	0.213
14	836	0.212
5	37031	0.211
25	624	0.204
21	620	0.204
19	618	0.204
17	616	0.204
20	619	0.203
7	1494580	0.203
16	615	0.203
18	617	0.194
13	834	0.194
1	36225	0.193
22	621	0.193
23	622	0.193
24	623	0.193
12	109373	0.184
15	139985	0.184
11	109372	0.184
10	109371	0.184
9	1494587	0.184
8	1494584	0.184
6	37033	0.184
4	37030	0.184
0	768	0.184



----- Graph 29 -----



----- Graph Stats -----

Nodes : 15 Edges : 15

Diameter : 8

Periphery : [12654, 12655, 631, 12794, 12604, 639]

Density of the graph: 0.13333333333333333

Average degree: 1.8666666666666667

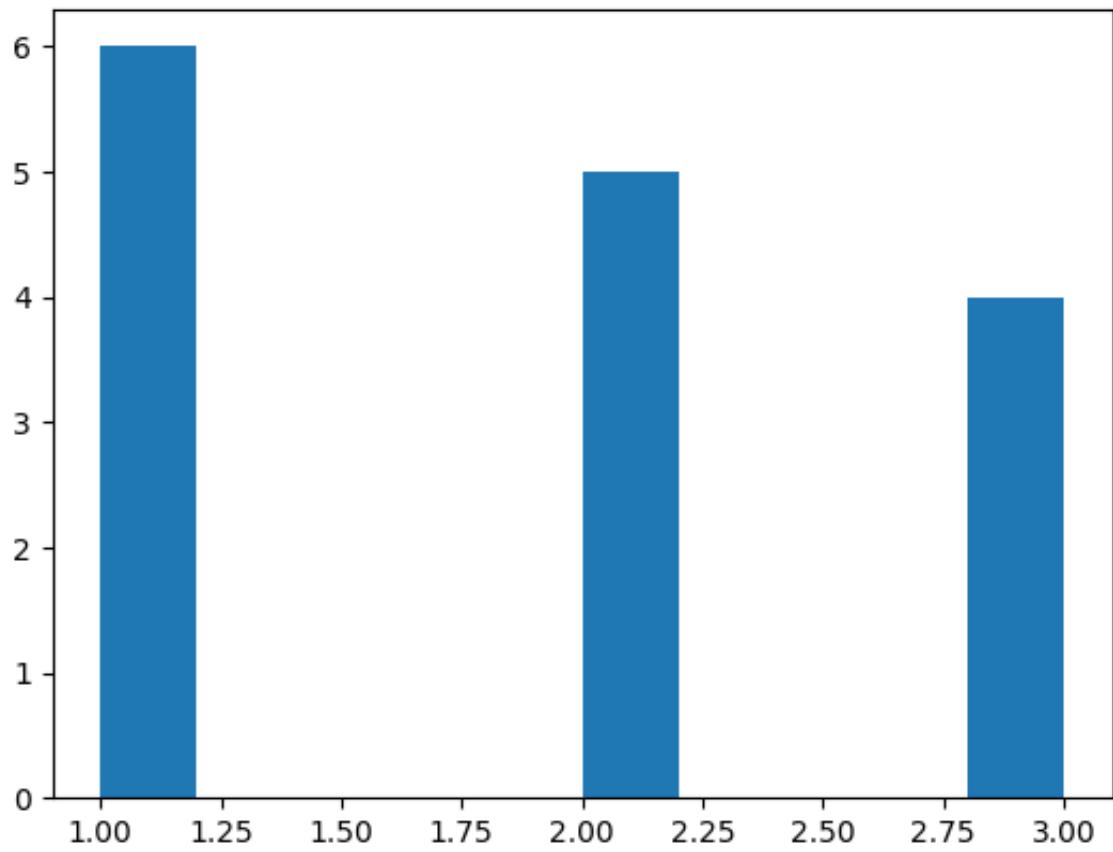
Size of the largest connected component: 15

Degree assortativity coefficient: -0.3162393162393155

	Node	Degree	Centrality
1	648	0	0.214
2	12653	0	0.214
5	625	0	0.214
9	629	0	0.214
0	12608	0	0.143
6	626	0	0.143
7	627	0	0.143
8	628	0	0.143
10	630	0	0.143
3	12654	0	0.071
4	12655	0	0.071
11	631	0	0.071
12	12794	0	0.071
13	12604	0	0.071
14	639	0	0.071

	Node	Closeness	Centrality
6	626	0.341	
5	625	0.333	
7	627	0.333	
8	628	0.311	
9	629	0.280	
1	648	0.275	
2	12653	0.275	
0	12608	0.230	

10	630	0.230
3	12654	0.219
4	12655	0.219
12	12794	0.219
14	639	0.219
11	631	0.189
13	12604	0.189
	Node	Betweenness Centrality
5	625	0.626
6	626	0.538
7	627	0.527
8	628	0.495
9	629	0.484
1	648	0.275
2	12653	0.275
0	12608	0.143
10	630	0.143
3	12654	0.000
4	12655	0.000
11	631	0.000
12	12794	0.000
13	12604	0.000
14	639	0.000
	Node	Katz Centrality
5	625	0.274
1	648	0.272
2	12653	0.272
9	629	0.272
6	626	0.260
7	627	0.260
8	628	0.260
0	12608	0.259
10	630	0.259
3	12654	0.247
4	12655	0.247
12	12794	0.247
14	639	0.247
11	631	0.246
13	12604	0.246



Graph Centralities

```
In [11]: print(f'Largest connected component : {max(nx.connected_components(G), key=len)}
```

```
Largest connected component : {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 2146, 36963, 36964, 36966, 36967, 104, 105, 106, 36971, 108, 109, 110, 111, 112, 113, 114, 107, 36974, 36975, 116, 119, 118, 117, 115, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 36992, 36993, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 2203, 2204, 2202, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 2220, 175, 176, 177, 178, 179, 180, 181, 182, 183, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 2256, 2258, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 327, 331, 332, 333, 338, 339, 340, 341, 342, 343, 344, 345, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 404, 405, 410, 411, 419, 420, 422, 423, 424, 425, 426, 427, 432, 433, 434, 435, 440, 441, 442, 443, 444, 452, 453, 454, 455, 460, 461, 462, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 521, 522, 523, 524, 525, 526, 536, 537, 538, 539, 540, 541, 542, 543, 548, 549, 550, 37415, 35405, 2155, 120, 2156, 121, 2157, 122, 2158, 2161, 37498, 156, 157, 41752, 41753, 41754, 41755, 41756, 41757, 41758, 41759, 41760, 41761, 41762, 41763, 41764, 174, 35695, 35696, 35698, 35699, 35703, 35709, 35710, 35717, 35728, 35729, 35731, 35734, 35735, 35739, 2219, 35746, 35747, 35748, 35749, 2221, 1610675, 35768, 35769, 35770, 35771, 35772, 35773, 35774, 35775, 35795, 35796, 35797, 35799, 35800, 35803, 35805, 35809, 35818, 35841, 35844, 35845, 35846, 35847, 35848, 35850, 35851, 35852, 35854, 35863, 1048, 1049, 1050, 1052, 1055, 1056, 1057, 1058, 35881, 1068, 1069, 1070, 1071, 1072, 1073, 1075, 1076, 2251, 1089, 1090, 2252, 42052, 42053, 42054, 1092, 1093, 1096, 42058, 1099, 1100, 1101, 2254, 1103, 1098, 42066, 42067, 1110, 42073, 42074, 42076, 42077, 42078, 42079, 1116, 42081, 42082, 1124, 35943, 35950, 1143, 3204, 1156, 1158, 1159, 1157, 1165, 1166, 1167, 3246, 3247, 3248, 3249, 3252, 3253, 3254, 3255, 3257, 36178, 36184, 36185, 36186, 36187, 36193, 36200, 36201, 36202, 36210, 36211, 36212, 36215, 36218, 36219, 36235, 42570, 42582, 42583, 42584, 42585, 42586, 42587, 42588, 42594, 42595, 42596, 42597, 42598, 159498, 3, 42600, 1594982, 1594984, 1594985, 36965, 1607298, 1607299, 32419, 36976, 36977, 36978, 36979, 36980, 36981, 36982, 36983, 36984, 36985, 36986, 36987, 36991, 1603442, 1603443, 1918, 1919, 1920, 158, 1593601}
```

```
In [12]: nx.diameter(G) # NetworkXError: Found infinite path length because the graph is not connected
```

```
--> NetworkXError: Found infinite path length because the graph is not connected
```

```

2
3 # Refer graph statistics for diameter details

/usr/local/lib/python3.10/dist-packages/networkx/utils/decorators.py in a
rgmap_diameter_27(G, e, usebounds, weight, backend, **backend_kwargs)
    1 import bz2
    2 import collections
----> 3 import gzip
    4 import inspect
    5 import itertools

/usr/local/lib/python3.10/dist-packages/networkx/utils/backends.py in __c
all__(self, backend, *args, **kwargs)
  631         if not backends:
  632             # Fast path if no backends are installed
--> 633             return self.orig_func(*args, **kwargs)
  634
  635         # Use `backend_name` in this function instead of `backend
`


/usr/local/lib/python3.10/dist-packages/networkx/algorithms/distance_meas
ures.py in diameter(G, e, usebounds, weight)
  379         return _extrema_bounding(G, compute="diameter", weight=we
ight)
  380     if e is None:
--> 381         e = eccentricity(G, weight=weight)
  382     return max(e.values())
  383

/usr/local/lib/python3.10/dist-packages/networkx/utils/decorators.py in a
rgmap_eccentricity_31(G, v, sp, weight, backend, **backend_kwargs)
    1 import bz2
    2 import collections
----> 3 import gzip
    4 import inspect
    5 import itertools

/usr/local/lib/python3.10/dist-packages/networkx/utils/backends.py in __c
all__(self, backend, *args, **kwargs)
  631         if not backends:
  632             # Fast path if no backends are installed
--> 633             return self.orig_func(*args, **kwargs)
  634
  635         # Use `backend_name` in this function instead of `backend
`


/usr/local/lib/python3.10/dist-packages/networkx/algorithms/distance_meas
ures.py in eccentricity(G, v, sp, weight)
  318         else:
  319             msg = "Found infinite path length because the gra
ph is not" " connected"
--> 320             raise nx.NetworkXError(msg)
  321
  322         e[n] = max(length.values())

```

`NetworkXError`: Found infinite path length because the graph is not connected

```
In [13]: # Density
density = nx.density(graph)
print(f"Density of the graph: {density}")

# Max and Min degree
degrees = dict(graph.degree())
max_degree = max(degrees.values())
min_degree = min(degrees.values())

# Average degree
avg_degree = (2 * num_edges) / num_nodes
print(f"Average degree: {avg_degree}")

# Number of connected components

connected_components = list(nx.connected_components(graph))
largest_component_size = max(len(c) for c in connected_components) # Find
print(f"Size of the largest connected component: {largest_component_size}")

# Degree assortativity
assortativity = nx.degree_assortativity_coefficient(graph)
print(f"Degree assortativity coefficient: {assortativity}")
```

Density of the graph: 0.1333333333333333
 Average degree: 1.8666666666666667
 Size of the largest connected component: 15
 Degree assortativity coefficient: -0.3162393162393155

Clustering Coefficient

```
In [14]: print(nx.clustering(G))
Clustering_coeff=nx.clustering(G)
res = {key : round(Clustering_coeff[key], 3) for key in Clustering_coeff}
df=pd.DataFrame(res.items(), columns=["Node", "Clustering_coeff"])
print(df.sort_values('Clustering_coeff', ascending=False))
df.to_csv('Clustering_coeff.csv')

{0: 0, 1: 0, 2: 0, 469: 0, 6: 0, 385: 0, 3: 0, 380: 0, 37415: 0, 5: 0.333
333333333333, 384: 0, 386: 0, 4: 0.1666666666666666, 419: 0, 422: 0, 9
8: 0.1666666666666666, 420: 0, 35698: 0, 183: 0, 423: 0, 470: 0, 35729:
0, 35709: 0, 7: 0, 8: 0, 9: 0.3333333333333333, 79: 0, 33: 0, 10: 0.33333
3333333333, 84: 0.1666666666666666, 78: 0, 119: 0, 32: 0, 34: 0, 11: 0.
33333333333333, 110: 0.3333333333333333, 83: 0, 85: 0, 12: 0.1666666666
6666666, 111: 0.3333333333333333, 112: 0.1666666666666666, 13: 0.1666666
666666666, 95: 0.3333333333333333, 108: 0.1666666666666666, 14: 0, 94:
0, 109: 0.3333333333333333, 113: 0.3333333333333333, 123: 0, 96: 0, 15:
0, 16: 0, 77: 0, 93: 0, 17: 0.1666666666666666, 18: 0.3333333333333333,
3254: 0.1666666666666666, 19: 0, 3255: 0, 36971: 0, 20: 0, 23: 0, 21: 0,
22: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 0, 29: 0, 30: 0, 31: 0, 3247: 0, 3
253: 0, 35943: 0, 3246: 0, 3248: 0, 3249: 0, 3204: 0, 35950: 0, 2203: 0,
3252: 0, 3257: 0, 2146: 0, 2204: 0, 35: 0, 36: 0, 50: 0, 1199: 0.33333333
33333333, 37: 0.3333333333333333, 35885: 0, 1645159: 0, 49: 0, 185: 0, 11
98: 0.1666666666666666, 1205: 1.0, 38: 0.3333333333333333, 1641586: 0.33
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```

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    Node Clustering_coeff
400    35703          1.0
270    6802          1.0
1068   7166          1.0
416    368           1.0
1283   22108          1.0
...
543    278           0.0
542    277           0.0
541    275           0.0
540    274           0.0
1409   12604          0.0

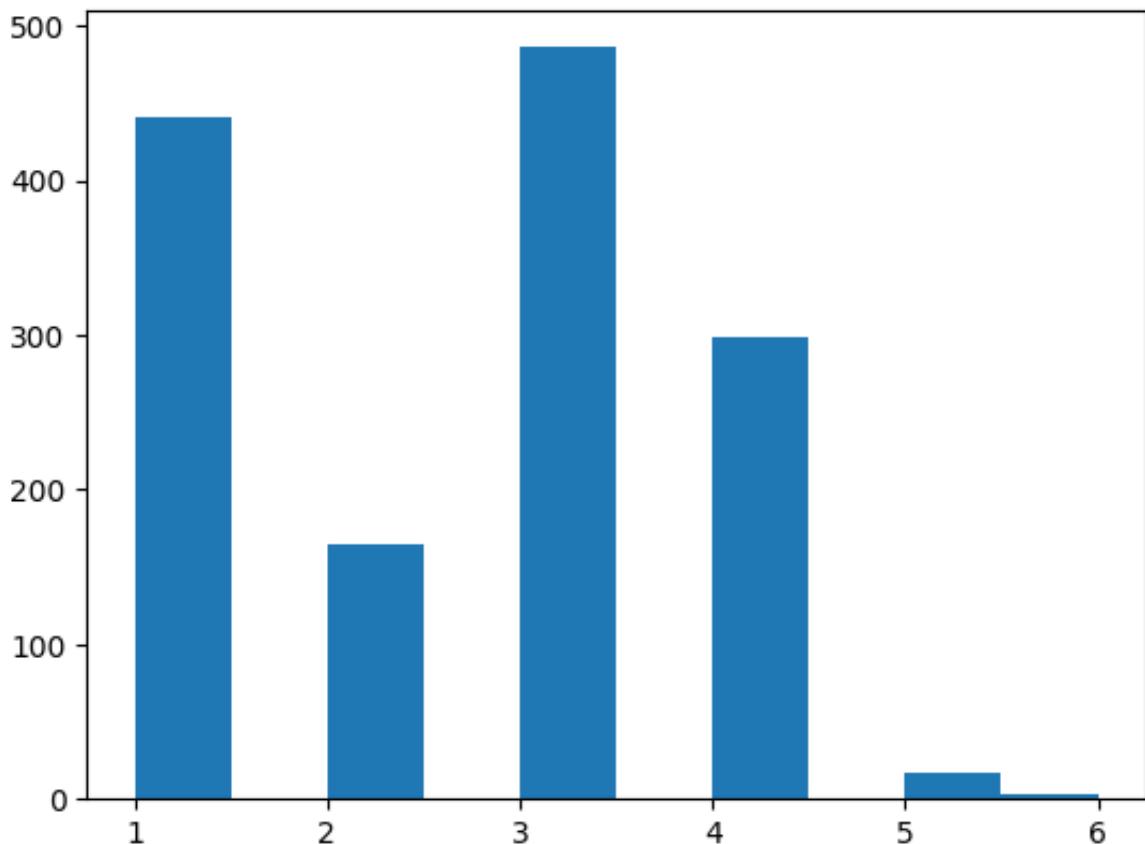
```

[1410 rows x 2 columns]

In [14]:

```
In [15]: #Degree plot for undirected and unweighted graph  
degrees = [G.degree(n) for n in G.nodes()]  
  
plt.hist(degrees)
```

```
Out[15]: (array([441., 0., 164., 0., 486., 0., 299., 0., 17., 3.]),  
 array([1., 1.5, 2., 2.5, 3., 3.5, 4., 4.5, 5., 5.5, 6.]),  
<BarContainer object of 10 artists>)
```



```
In [16]: deg_centrality=nx.degree_centrality(G)  
res = {key : round(deg_centrality[key], 3) for key in deg_centrality}  
df=pd.DataFrame(res.items(), columns=["Node", "Degree Centrality"])  
print(df.sort_values('Degree Centrality', ascending=False))  
df.to_csv('Degree_Centrality.csv')
```

Node	Degree Centrality
260	0.004
685	0.004
756	0.004
1275	0.004
259	0.004
...	...
745	0.001
746	0.001
757	0.001
759	0.001
1409	0.001

[1410 rows x 2 columns]

```
In [17]: Closeness_centrality=nx.closeness_centrality(G)
res = {key : round(Closeness_centrality[key], 3) for key in Closeness_cen
df=pd.DataFrame(res.items(), columns=["Node", "Closeness Centrality"])
print(df.sort_values('Closeness Centrality',ascending=False))
df.to_csv('Closeness_Centrality.csv')
```

	Node	Closeness Centrality
316	356	0.032
414	351	0.032
242	129	0.032
410	190	0.032
457	211	0.032
...
1242	563	0.002
1241	562	0.002
1409	12604	0.002
677	319	0.001
678	320	0.001

[1410 rows x 2 columns]

```
In [18]: Betweenness_centrality=nx.betweenness_centrality(G)
res = {key : round(Betweenness_centrality[key], 3) for key in Betweenness
df=pd.DataFrame(res.items(), columns=["Node", "Betweenness Centrality"])
print(df.sort_values('Betweenness Centrality',ascending=False))
df.to_csv('Betweenness_Centrality.csv')
```

	Node	Betweenness Centrality
359	303	0.039
665	305	0.037
663	302	0.036
458	212	0.033
590	263	0.032
...
709	4132	0.000
711	36980	0.000
712	328	0.000
713	329	0.000
1409	12604	0.000

[1410 rows x 2 columns]

```
In [19]: Katz_centrality=nx.katz_centrality(G,alpha=0.05, beta=1.0, max_iter=1000,
res = {key : round(Katz_centrality[key], 3) for key in Katz_centrality}
df=pd.DataFrame(res.items(), columns=["Node", "Katz Centrality"])
print(df.sort_values('Katz Centrality',ascending=False))
df.to_csv('Katz_Centrality.csv')
```

	Node	Katz Centrality
1275	585	0.031
276	6738	0.031
808	457	0.031
756	3339	0.030
1049	7154	0.030
...
792	12231	0.024
640	35771	0.024
677	319	0.024
678	320	0.024
1409	12604	0.024

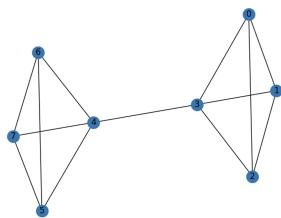
[1410 rows x 2 columns]

Observations

1. **High clustering in local neighborhoods** (e.g., residential areas) and **low clustering in main roads or highways**.
2. **Urban grids** lead to higher clustering, especially at intersections where multiple roads meet. These components are strongly connected.
3. **Hierarchical structures** often emerge, with central roads having low clustering and peripheral roads showing more clustering.
4. **Traffic bottlenecks** can be detected by finding intersections with low clustering but high connectivity.

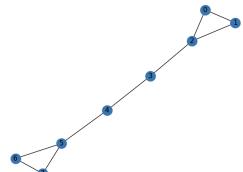
Question 2 a																		
Node	Degree	Degree Centrality							Distance from node									
		0	1	2	3	4	5	6	7	Distance	Closeness	Normalized Closeness	Betweenness Centrality					
0	3	0.4285714286	0	1	1	2	3	3	3	14	0.07142857143	0.5	0					
1	3	0.4285714286	1	0	1	1	2	3	3	14	0.07142857143	0.5	0					
2	3	0.4285714286	1	1	0	1	2	3	3	14	0.07142857143	0.5	0					
3	4	0.5714285714	1	1	1	0	1	2	2	10	0.1	0.7	0.5714285714					
4	4	0.5714285714	2	2	2	1	0	1	1	10	0.1	0.7	47					
5	3	0.4285714286	3	3	3	2	1	0	1	14	0.07142857143	0.5	0					
6	3	0.4285714286	3	3	3	2	1	1	0	14	0.07142857143	0.5	0					
7	3	0.4285714286	3	3	3	2	1	1	0	14	0.07142857143	0.5	0					

a)



Question 2 b																		
Node	Degree	Degree Centrality							Distance from node									
		0	1	2	3	4	5	6	7	Distance	Closeness	Normalized Closeness	Betweenness Centrality					
0	2	0.2857142857	0	1	1	2	3	4	5	21	0.04761904762	0.3333333333	0					
1	2	0.2857142857	1	0	1	2	3	4	5	21	0.04761904762	0.3333333333	0					
2	3	0.4285714286	1	1	0	1	2	3	4	16	0.0625	0.4375	0.4761904762					
3	2	0.2857142857	2	2	1	0	1	2	3	14	0.07142857143	0.5	0.5714285714					
4	2	0.2857142857	3	3	2	1	0	1	2	14	0.07142857143	0.5	0.5714285714					
5	3	0.4285714286	4	4	3	2	1	0	1	16	0.0625	0.4375	0.4761904762					
6	2	0.2857142857	5	5	4	3	2	1	0	1	21	0.04761904762	0.3333333333	0				
7	2	0.2857142857	5	5	4	3	2	1	1	0	21	0.04761904762	0.3333333333	0				

b)

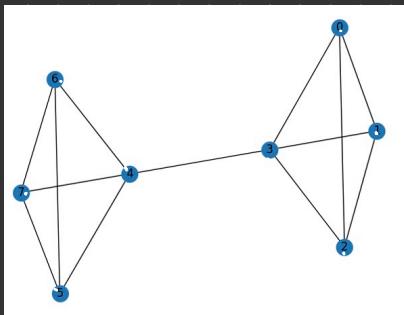


Rough Work

for

Question 2
 $(276 - HW1)$

-Rudraksh Naik
018173285



$$N = 8$$

0 1 2 3 4 5 6 7

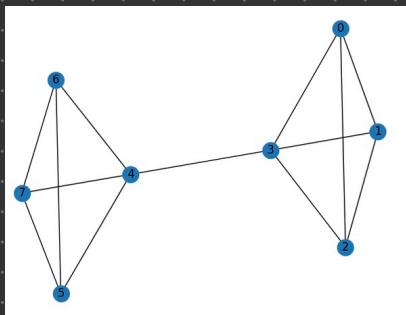
degree

3 3 3 4 4 3 3 3

degree
centrality

$\frac{3}{7}$ $\frac{3}{7}$ $\frac{3}{7}$ $\frac{4}{7}$ $\frac{4}{7}$ $\frac{3}{7}$ $\frac{3}{7}$

$$= \frac{d(n)}{N - 1}$$

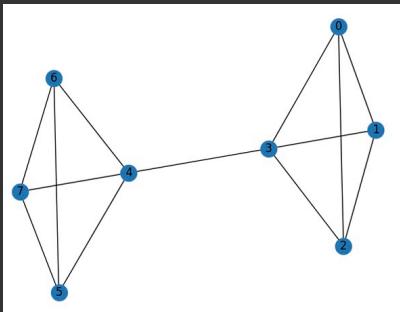


	0	1	2	3	4	5	6	7
0	0	1	1	1	2	3	3	3
1	1	0	1	1	2	3	3	3
2	1	1	0	1	2	3	3	3
3	1	1	1	0	1	2	2	2
4	2	2	2	1	0	1	1	1
5	3	3	3	2	1	0	1	1
6	3	3	3	2	1	1	0	1
7	3	3	3	2	1	1	1	0

node	distance	closeness	normalized closeness
0	14	1/14	7/14
1	14	1/14	7/14
2	14	1/14	7/14
3	10	1/10	7/10
4	10	1/10	7/10
5	14	1/14	7/14
6	14	1/14	7/14
7	14	1/14	7/14

$$\text{closeness} = \text{distance}^{-1}$$

$$\text{normalized closeness} = \frac{\text{closeness}}{\text{closeness}} \times (N-1)$$



$v_1 v_2$

v_6

$v_1 v_3$

0

$v_1 v_4$

0

$v_1 v_5$

0

$v_1 v_6$

0

$v_1 v_7$

0

$$C_b(v_0) = \emptyset = C_b(v_1) = C_b(v_2)$$

$$C_b(v_6) = C_b(v_7) = C_b(v_5) = \emptyset$$

$v_6 v_1$

v_3

$v_6 v_2$

0

$v_6 v_4$

0

$v_6 v_5$

$1/1$

$v_6 v_6$

$1/1$

$v_6 v_7$

$1/1$

$v_1 v_2$

0

$v_1 v_4$

$1/1$

$v_1 v_5$

$1/1$

$v_1 v_6$

$1/1$

$v_1 v_7$

$1/1 = 4$

$v_2 v_4$

$1/1$

$1/1$

$1/1$

$1/1$

$$\frac{+2 \times 2}{7 \times 6} = \frac{4}{7}$$

$$V_0 V_5 \quad V_0 V_6 \quad V_0 V_7$$

$$V_4 \quad 1/1 \quad 1/1 \quad 1/1 = 3$$

$$V_1 V_5 \quad . \quad 1/1 \quad 1/1 = 3$$

$$V_2 \quad . \quad 1/1 \quad 1/1 = 3$$

$$V_3 \quad . \quad 1/1 \quad 1/1 = 3$$

$$4 \quad \frac{+2 \times 2}{7 \times 6} = \frac{4}{7}$$

$$C_b(v_3) = C_b(v_4) = 4/7$$

—

—

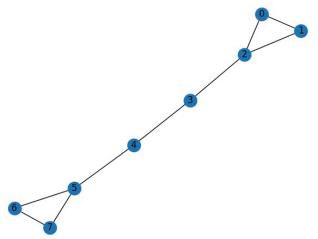
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b)

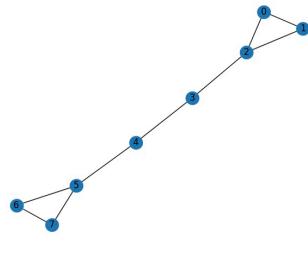


node	degree	degree centrality
0	2	2/7
1	2	2/7
2	3	3/7
3	2	2/7
4	2	2/7
5	3	3/7
6	2	2/7
7	2	2/7

node	0	1	2	3	4	5	6	7
0	0	1	1	2	3	4	5	5
1	1	0	1	2	3	4	5	5
2	1	1	0	1	2	3	4	4
3	2	2	1	0	1	2	3	3
4	3	3	2	1	0	1	2	2
5	4	4	3	2	1	0	1	1
6	5	5	4	3	2	1	0	1
7	5	5	4	3	2	1	1	0

node	distance	closeness	normalized closeness
0	21	1/21	7/21
1	21	1/21	7/21
2	16	1/16	7/16
3	14	1/14	7/14
4	14	1/14	7/14
5	16	1/16	7/16
6	21	1/21	7/21
7	21	1/21	7/21

b)



Similar Nodes:

 $[0, 1, 6, 7]$ $[2, 5]$ $[3, 4]$

centralities of
these nodes in the same list
will be the same

$$C_b(v_6) =$$

v_1v_2	v_1v_3	v_1v_4	v_1v_5	v_1v_6	v_1v_7
0	0	0	0	0	0

v_2v_3	v_2v_4	v_2v_5	v_2v_6	v_2v_7
0	0	0	0	0

v_3v_4	v_3v_5	v_3v_6	v_3v_7
0	0	0	0

v_4v_5	v_4v_6	v_4v_7
0	0	0

v_5v_6	v_5v_7
----------	----------

0	0
---	---

v_6v_7

0

v_0v_1	v_0v_3	v_0v_4	v_0v_5	v_0v_6	v_0v_7
----------	----------	----------	----------	----------	----------

$$C_b(v_2) = 0 \quad 1/1 \quad 1/1 \quad 1/1 \quad 1/1 \quad 1/1 \quad = 5$$

v_1v_3	v_1v_4	v_1v_5	v_1v_6	v_1v_7
1/1	1/1	1/1	1/1	1/1

$$v_3 v_4 \quad - - - \quad v_6 v_7$$

$$\frac{10 \times 2}{7 \times 6}$$

$$C_b(v_2) = \frac{10}{21}$$

$$\frac{10}{21}$$

$$C_b(v_2) = C_b(v_5) = \frac{10}{21}$$

$$v_0 v_1 \quad v_0 v_2 \quad v_0 v_4 \quad v_0 v_5 \quad v_0 v_6 \quad v_0 v_7$$

$$0 \quad 0 \quad 1/1 \quad 1/1 \quad 1/1 \quad 1/1 = 4$$

$$C_b(3) =$$

$$v_1 v_2 \quad v_1 v_4 \quad v_1 v_5 \quad v_1 v_6 \quad v_1 v_7$$

$$0 \quad 1/1 \quad 1/1 \quad 1/1 \quad 1/1 = 4$$

$$v_2 v_4 \quad v_2 v_5 \quad v_2 v_6 \quad v_2 v_7$$

$$1/1 \quad 1/1 \quad 1/1 \quad 1/1 = 4$$

$$v_4 v_5 \quad - \quad v_6 v_7 = 0$$

$$\frac{2}{7 \times 6} = \frac{4}{7}$$

$$C_b(v_2) = \frac{4}{7}$$

$$C_b(v_2) = C_b(v_3) = 4/7$$