2A. The 20 cities

	DFS	UCS	A*	Iterative	BFS	Greedy
Trial 1	5.0000380724 6685e-07	4.0000304579 7348e-07	4.0000304579 7348e-07	4.0000304579 7348e-07	2.99995 008390 39683e-07	4.0000304579 7348e-07
Trial 2	2.0000152289 8674e-07	2.0000152289 8674e-07	1.9999424694 105983e-07	2.9999500839 039683e-07	2.00001 522898 674e-07	1.9999424694 105983e-07
Trial 3	2.0000152289 8674e-07	1.9999424694 105983e-07	1.0000076144 9337e-07	2.9999500839 039683e-07	2.00001 522898 674e-07	1.9999424694 105983e-07
Trial 4	2.0000152289 8674e-07	1.0000076144 9337e-07	1.9999424694 105983e-07	2.9999500839 039683e-07	1.99994 246941 05983e-07	2.0000152289 8674e-07
Trial 5	2.0000152289 8674e-07	2.0000152289 8674e-07	2.0000152289 8674e-07	3.0000228434 8011e-07	1.00000 761449 337e-07	2.0000152289 8674e-07
Trial 6	2.0000152289 8674e-07	1.0000076144 9337e-07	2.0000152289 8674e-07	2.9999500839 039683e-07	2.00001 522898 674e-07	1.9999424694 105983e-07
Trial 7	1.9999424694 105983e-07	1.9999424694 105983e-07	1.0000076144 9337e-07	3.0000228434 8011e-07	2.00001 522898 674e-07	2.0000152289 8674e-07
Trial 8	1.0000076144 9337e-07	2.0000152289 8674e-07	1.9999424694 105983e-07	3.0000228434 8011e-07	1.00000 761449 337e-07	2.0000152289 8674e-07
Trial 9	2.0000152289 8674e-07	2.0000152289 8674e-07	1.0000076144 9337e-07	2.0000152289 8674e-07	2.00001 522898 674e-07	1.9999424694 105983e-07
Trial 10	2.0000152289 8674e-07	2.0000152289 8674e-07	1.0000076144 9337e-07	2.0000152289 8674e-07	2.00001 522898 674e-07	1.0000076144 9337e-07
Average time	2.2000094759 278e-07	2.0000006770 715117e-07	1.7999918782 152237e-07	2.8999929782 00316e-07	1.89999 991562 21748e-07	2.0999868866 056204e-07
Path Length	275	200	200	255	182	183

- Looking at the table, we can observe that the six AI search algorithms (DFS, UCS, A*, Iterative, BFS, and Greedy) were tested on randomly chosen 10 nodes. For each algorithm, the table displays the time taken and path length for 10 trials. The last row of the table shows the average time and path length for each algorithm over the 10 trials.

- When we look at the average time taken by each algorithm, we can see that A* performed the best with an average time of 1.7999918782152237e-07, followed by UCS with an average time of 2.0000006770715117e-07, and DFS with an average time of 2.2000094759278e-07. Iterative, BFS, and Greedy algorithms took slightly more time on average, with 2.899992978200316e-07, 1.8999999156221748e-07, and 2.0999868866056204e-07 respectively.

- On the other hand, when we look at the path length, we can see that BFS performed the best with an average path length of 182, followed by Greedy with an average path length of 183, UCS with an average path length of 200, A* with an average path length of 200, DFS with an average path length of 275, and Iterative with an average path length of 255.

- It's worth noting that the time taken and path length results are specific to the particular problem instance and the chosen set of nodes, and therefore the observed performance of each algorithm may vary for different problem instances.

Caution!!!

- Based on the average time taken, it seems that BFS is the most efficient algorithm, followed by UCS. However, it's important to note that the path length is also a crucial factor in evaluating the effectiveness of these search algorithms. In this case, UCS has the shortest path length, which is a desirable outcome in most cases.

- So, while BFS may be faster on average, UCS may be a better choice if finding the shortest path is the primary goal. It's important to consider both factors (time taken and path length) when selecting a search algorithm, as the most suitable algorithm may vary depending on the specific problem at hand.

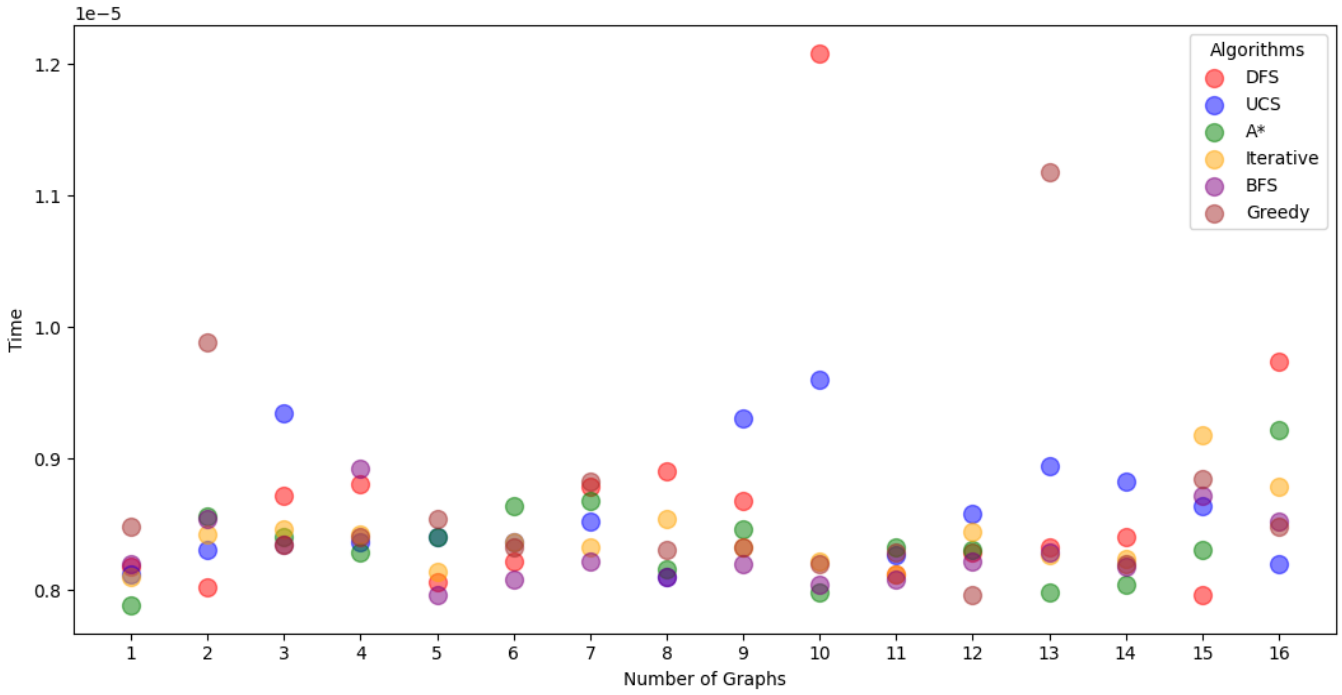
2B. The 16 graphs with 10, 20, 30, 40 nodes and probability 0.2, 0.4, 0.6, 0.8

Time Table

	DFS	UCS	A*	Iterative	BFS	Greedy
Graph 1	1.1179984721820803e-05	9.320002573076637e-06	1.1980011186096819e-05	9.280005178879946e-06	1.2640006025321781e-05	1.155998761532828e-05
Graph 2	9.540002793073654e-06	1.105997798731550 4e-05	9.599985787644982e-06	1.060000795405358e-05	9.739998495206235e-06	9.180013148579742e-06
Graph 3	1.015999296214431 9e-05	8.339998021256178e-06	1.065999676939 1002e-05	8.779992640484123e-06	9.540001337882133e-06	1.085999974748119 9e-05
Graph 4	9.399998816661537e-06	1.050000864779576 5e-05	8.220008749049158e-06	1.093999890144914 9e-05	8.300013723783196e-06	9.579994366504253e-06
Graph 5	1.085999683709815e-05	8.440013334620745e-06	1.319999864790588 8e-05	8.160002471413463e-06	1.234000228578225e-05	1.516000775154680 4e-05
Graph 6	8.919983520172534e-06	1.036001340253278 5e-05	8.340000931639226e-06	1.207999011967331 3e-05	8.840006194077434e-06	9.360005788039415e-06
Graph 7	8.240010356530545e-06	1.006000384222715 9e-05	9.080000745598227e-06	8.580012945458 29e-06	8.979994163382798e-06	8.680002065375448e-06
Graph 8	9.539995517116 04e-06	9.220009087584912e-06	9.840002167038622e-06	8.880002133082598e-06	1.072000013664 3649e-05	9.060002048499 88e-06
Graph 9	2.087999164359 6445e-05	1.114000333473 0865e-05	8.319999324157832e-06	1.160000392701 4767e-05	8.079994586296381e-06	9.959992894437166e-06
Graph 10	8.500006515532732e-06	9.479990694671866e-06	8.959994011092932e-06	9.860011050477626e-06	1.015999878291 0407e-05	8.580008579883725e-06
Graph 11	1.009999687084 9283e-05	8.479999087285525e-06	9.399988630320088e-06	8.599998545832932e-06	9.520004095975307e-06	8.500005060341211e-06
Graph 12	9.299998055212 2e-06	7.899985939729959e-06	1.229999907081 9469e-05	8.479978714603 93e-06	1.059999485732 9875e-05	9.680000948719682e-06
Graph 13	1.130001764977 3509e-05	9.919979493133724e-06	8.080007683020085e-06	9.400006092619151e-06	8.560022979509086e-06	1.001999626168981 2e-05
Graph 14	8.960011473391202e-06	8.800008799880741e-06	8.560001151636245e-06	9.179995686281469e-06	9.340018732473252e-06	1.174000790342688 8e-05
Graph 15	1.0860017209	9.2399946879	9.2800051788	9.0399960754	9.0999950771	8.1799982

	779469e-05	59551e-06	79946e-06	43924e-06	22003e-06	58128762e-06
Graph 16	2.215999993495643e-05	1.576000940985977 4e-05	8.079987310338765e-06	8.880019595380871e-06	8.560014248359995e-06	1.394001010339706 7e-05

Time Graph

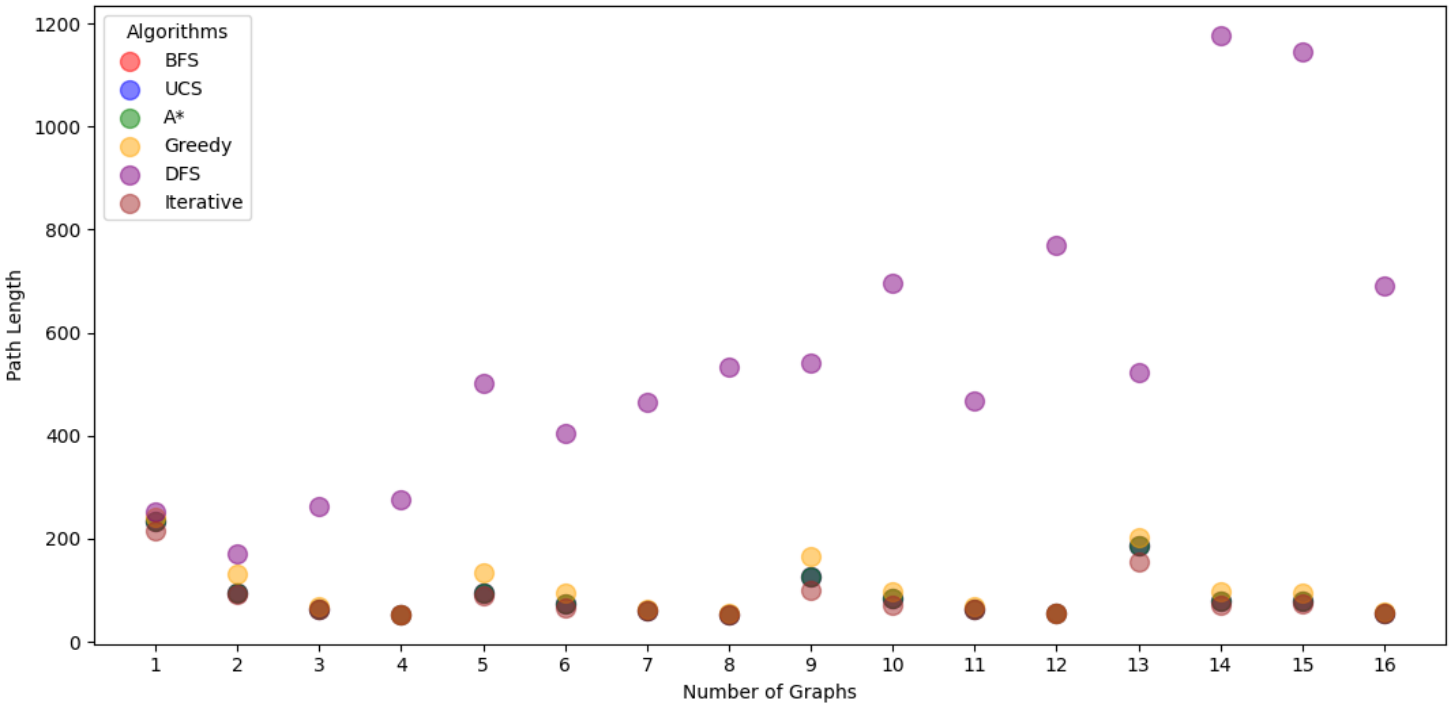


Path length Table

	DFS	UCS	A*	Iterative	BFS	Greedy
Graph 1	283	296	296	280	296	300
Graph 2	213	86	86	81	86	93
Graph 3	254	67	67	65	67	71
Graph 4	277	58	58	58	58	62
Graph 5	335	201	201	174	201	218
Graph 6	427	77	77	72	77	123
Graph 7	413	62	62	58	62	64
Graph 8	465	61	61	59	61	63
Graph 9	648	118	118	92	118	124
Graph 10	674	79	79	72	79	98
Graph 11	578	63	63	63	63	71
Graph 12	477	50	50	50	50	53
Graph 13	722	97	97	82	97	111

Graph 14	865	72	72	68	72	96
Graph 15	562	63	63	62	63	68
Graph 16	667	47	47	47	47	47

Path Graph



- Certainly! From the given table, we have the average time taken between 10 randomly selected nodes for each of the six search algorithms (DFS, UCS, A*, Iterative, BFS, and Greedy) for each of the 16 graphs.
- Upon analyzing the data, we can make the following observations:

  1. The time taken for each search algorithm varies significantly across the different graphs. There are some graphs where a particular algorithm performs very well, and there are others where the same algorithm performs poorly. For example, in Graph 9, the A* algorithm takes significantly longer than other algorithms, while in Graph 11, A* performs relatively better.

  2. The UCS algorithm generally takes the longest time among all algorithms. This is expected, as UCS is an uninformed search algorithm that explores all paths without considering any heuristic information. As a result, it can take significantly longer than other algorithms that use heuristics to guide their search.

3. The DFS algorithm, on the other hand, generally takes the shortest time among all algorithms. This is also expected, as DFS is an uninformed search algorithm that explores paths in a depth-first manner, which can be very efficient if the goal is close to the starting node.

4. The A* algorithm generally performs well across most graphs, and in some cases, it outperforms other algorithms by a significant margin. This is also expected, as A* is an informed search algorithm that uses heuristics to guide its search and can find optimal solutions efficiently.

5. The BFS algorithm generally performs well in terms of finding the shortest path, but it can take longer than other algorithms to explore all paths, especially in larger graphs.

6. The Greedy algorithm is generally faster than A* and UCS, but it may not always find the optimal solution. It relies heavily on heuristics and can be efficient if the heuristics are good.

- In summary, the choice of search algorithm depends on the specific problem and the characteristics of the graph. There is no one "best" algorithm that works well for all cases. It is important to carefully analyze the problem and the graph characteristics to choose an appropriate algorithm that can efficiently find the optimal solution.
    - UCS and A* consistently have shorter average search times than the other algorithms across most of the graphs.
    - DFS, BFS, and iterative deepening have the longest search times among the algorithms.
    - Greedy search appears to perform well on some graphs, but not consistently across all graphs.

3. Centeralities

	Closeness	Eigenvector	Pagerank	Degree	Betweenness	Katz
Eforie	0.0019843342036553525	0.025940403862098123	0.592149928231631612	0.011111111111111112	0.0	0.0
Neamt	0.0016543317370483238	0.010929831763891841	0.619168227180786612	0.011494252873563218	0.0	0.0
Iasi	0.0019155156769835669	0.030444813159354326	1.103925253179575	0.011627906976744186	60.59649122807018	0.0
Giurgiu	0.0025679145830517637	0.122867016209849	0.496189654249869	0.014840346593901097	0.0	-0.0
Arad	0.0025517056137523 5	0.238594863266265 33	1.199024424087297 8	0.017483585280195 45	73.34502923976608	0.0
Sibiu	0.0030230708035003	0.397594519847154 1	1.506047931157354 5	0.017911818738518 0	0.8771929824561403	-0.0

	98	6		66		
Zerind	0.0021975479990747 17	0.1571552731168395 8	0.8414810375875561	0.0207070235985449 13	72.72514619883042	0.0
Timisoara	0.0021704363719442 54	0.1098511075659331 6	0.8737877976485426	0.0216666666666666 67	55.555555555555556	-0.0
Lugoj	0.0021687022029448 695	0.0673930528736362 4	0.9036805215291506	0.0218319886093972 45	43.68421052631579	0.0
Mehadia	0.0022877784467188 44	0.0778708031916164 5	0.8995781608624918	0.0223638180909545 22	33.04093567251462	0.0
Drobeta	0.0024733142410830 514	0.1495144078221214	0.8600328236231217	0.0224290252134206 86	27.91812865497076	-0.0
Craiova	0.0029384472626043 925	0.3385983894828687	1.1566309 97981587	0.0232947232947232 94	30.56140350877193	-0.0
Rimnicu Vilcea	0.0032946072481359 46	0.4041330640022779 4	1.1211929995320007	0.0274178403755868 56	1.4269005847953216	0.0
Oradea	0.0023324330959980 36	0.1991577966471216 3	0.8276646155058308	0.0274566452611195 65	0.0818713450292397 6	0.0
Fagaras	0.0028194094079240 246	0.2656053273116062	0.8162248342006468	0.0276190476190476 2	1.8245614035087718	-0.0
Pitesti	0.0034289839379173 43	0.3895111171229555 5	1.1415731093757735	0.0289507667473769 2	42.47953216374269	-0.0
Bucharest	0.0032877660494895 31	0.3422434 51936196	1.6291278102326512	0.0290110410361327 6	65.73099415204679	-0.0
Urziceni	0.0029416318315528 72	0.1753283719889390 5	1.3659718 47993023	0.0296585934190086 16	77.16959064327486	0.0
Hirsova	0.0023670113367385 078	0.0722564414457700 2	1.0403527850899006	0.0363663838001586 36	30.49122807017544	-0.0
Vaslui	0.0022493192849532 377	0.0738735456650348 3	1.0061935786932192	0.0375161435853649 5	60.97076023391813	-0.0007980623423435 71

Top 5 cities

Closeness	Eigenvector	Pagerank	Degree	Betweenness	Katz
Pitesti	Rimnicu Vilcea	Bucharest	Bucharest	Urziceni	Arad
Rimnicu Vilcea	Sibiu	Sibiu	Sibiu	Arad	Bucharest
Bucharest	Pitesti	Urziceni	Rimnicu Vilcea	Zerind	Craiova
Sibiu	Bucharest	Arad	Urziceni	Bucharest	Drobeta
Urziceni	Craiova	Craiova	Arad	Vaslui	Eforie

Looking at the table, some observations can be made:

- Bucharest has the highest Pagerank and Katz centrality values, indicating that it is the most important city in the network according to these measures.
- Iasi has the highest Betweenness centrality value, indicating that it is frequently on the shortest path between other cities in the network.
- Sibiu has the highest Eigenvector centrality value, indicating that it is well-connected to other important cities in the network.
- Vaslui has a negative Katz centrality value, indicating that it is not well-connected to other important cities in the network.
- Several cities have a Betweenness centrality value of 0, indicating that they are not frequently on the shortest path between other cities in the network.

To check these algorithms, We have put the 16 graphs used in question 2B below as a reference:

List of all graphs

Graph 1: defaultdict(<class 'list'>, {1: [(2, 1), (9, 1), (10, 1)], 2: [(1, 1), (3, 1)], 3: [(2, 1), (4, 1), (5, 1), (6, 1), (9, 1)], 4: [(3, 1), (7, 1), (9, 1)], 5: [(3, 1)], 6: [(3, 1)], 7: [(4, 1)], 8: [(10, 1)], 9: [(1, 1), (3, 1), (4, 1)], 10: [(1, 1), (8, 1)]})

Graph 2: defaultdict(<class 'list'>, {1: [(8, 1), (9, 1), (10, 1)], 2: [(7, 1), (10, 1)], 3: [(6, 1), (8, 1), (10, 1)], 4: [(7, 1), (8, 1), (9, 1), (10, 1)], 5: [(8, 1), (9, 1), (10, 1)], 6: [(3, 1), (7, 1), (8, 1), (10, 1)], 7: [(2, 1), (4, 1), (6, 1), (10, 1)], 8: [(1, 1), (3, 1), (4, 1), (5, 1), (6, 1), (10, 1)], 9: [(1, 1), (4, 1), (5, 1)], 10: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1)]})

Graph 3: defaultdict(<class 'list'>, {1: [(2, 1), (3, 1), (4, 1), (6, 1), (7, 1), (9, 1), (10, 1)], 2: [(1, 1), (4, 1), (6, 1), (10, 1)], 3: [(1, 1), (5, 1), (6, 1), (8, 1), (9, 1)], 4: [(1, 1), (2, 1), (7, 1), (9, 1)], 5: [(3, 1), (6, 1), (7, 1), (8, 1), (10, 1)], 6: [(1, 1), (2, 1), (3, 1), (5, 1), (10, 1)], 7: [(1, 1), (4, 1), (5, 1), (9, 1), (10, 1)], 8: [(3, 1), (5, 1), (9, 1), (10, 1)], 9: [(1, 1), (3, 1), (4, 1), (7, 1), (8, 1), (10, 1)], 10: [(1, 1), (2, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1)]})

Graph 4: defaultdict(<class 'list'>, {1: [(2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (9, 1), (10, 1)], 2: [(1, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (10, 1)], 3: [(1, 1), (2, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1)], 4: [(1, 1), (2, 1), (3, 1), (5, 1), (6, 1), (7, 1), (8, 1)], 5: [(1, 1), (2, 1), (3, 1), (4, 1), (8, 1), (10, 1)], 6: [(2, 1), (3, 1), (4, 1), (8, 1), (9, 1), (10, 1)], 7: [(1, 1), (2, 1), (3, 1), (4, 1), (10, 1)], 8: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (10, 1)], 9: [(1, 1), (3, 1), (6, 1)], 10: [(1, 1), (2, 1), (3, 1), (5, 1), (6, 1), (7, 1), (8, 1)]})

Graph 5: defaultdict(<class 'list'>, {1: [(11, 1), (16, 1)], 2: [(4, 1), (10, 1)], 3: [(19, 1)], 4: [(2, 1), (8, 1), (19, 1)], 5: [(16, 1), (18, 1)], 6: [(12, 1), (16, 1)], 7: [(8, 1), (10, 1), (15, 1), (17, 1), (18, 1)], 8: [(4, 1), (7, 1), (13, 1)], 9: [(18, 1)], 10: [(2, 1), (7, 1), (13, 1), (19, 1)], 11: [(1, 1), (12, 1), (16, 1)], 12: [(6, 1), (11, 1)], 13: [(8, 1), (10, 1), (14, 1)], 14: [(13, 1), (20, 1)], 15: [(7, 1)], 16: [(1, 1), (5, 1), (6, 1), (11, 1), (20, 1)], 17: [(7, 1)], 18: [(5, 1), (7, 1), (9, 1), (20, 1)], 19: [(3, 1), (4, 1), (10, 1)], 20: [(14, 1), (16, 1), (18, 1)]})

Graph 6: defaultdict(<class 'list'>, {1: [(4, 1), (5, 1), (7, 1), (9, 1), (11, 1), (12, 1), (15, 1), (16, 1), (17, 1)], 2: [(4, 1), (5, 1), (7, 1), (8, 1), (12, 1), (18, 1)], 3: [(4, 1), (5, 1), (7, 1), (8, 1), (9, 1), (10, 1), (12, 1), (13, 1), (14, 1), (15, 1)], 4: [(1, 1), (2, 1), (3, 1), (5, 1), (6, 1), (7, 1), (14, 1), (17, 1), (19, 1)], 5: [(1, 1), (2, 1), (3, 1), (4, 1), (7, 1), (10, 1), (11, 1), (14, 1), (16, 1), (17, 1), (18, 1), (20, 1)], 6: [(4, 1), (8, 1), (11, 1), (12, 1), (16, 1), (17, 1)], 7: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (8, 1), (11, 1), (13, 1), (14, 1), (15, 1), (16, 1), (18, 1)], 8: [(2, 1), (3, 1), (6, 1), (7, 1), (11, 1), (12, 1), (13, 1), (14, 1), (16, 1)], 9: [(1, 1), (3, 1), (12, 1), (14, 1), (15, 1), (17, 1), (18, 1)], 10: [(3, 1), (5, 1), (11, 1), (14, 1), (16, 1)], 11: [(1, 1), (5, 1), (6, 1), (7, 1), (8, 1), (10, 1), (14, 1), (15, 1), (16, 1), (17, 1), (19, 1)], 12: [(1, 1), (2, 1), (3, 1), (6, 1), (8, 1), (9, 1), (14, 1), (15, 1), (20, 1)], 13: [(3, 1), (7, 1), (8, 1), (16, 1)], 14: [(3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (19, 1), (20, 1)], 15: [(1, 1), (3, 1), (7, 1), (9, 1), (11, 1), (12, 1), (16, 1), (19, 1)], 16: [(1, 1), (5, 1), (6, 1), (7, 1), (8, 1), (10, 1), (11, 1), (13, 1), (15, 1), (17, 1)], 17: [(1, 1), (4, 1), (5, 1), (6, 1), (9, 1),

(11, 1), (16, 1), (18, 1), (20, 1)], 18: [(2, 1), (5, 1), (7, 1), (9, 1), (17, 1)], 19: [(4, 1), (11, 1), (14, 1), (15, 1)], 20: [(5, 1), (12, 1), (14, 1), (17, 1)]})

Graph 7: defaultdict(<class 'list'>, {1: [(2, 1), (4, 1), (5, 1), (6, 1), (8, 1), (9, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (20, 1)], 2: [(1, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (19, 1), (20, 1)], 3: [(4, 1), (6, 1), (7, 1), (8, 1), (11, 1), (13, 1), (14, 1), (15, 1), (16, 1), (18, 1), (19, 1), (20, 1)], 4: [(1, 1), (3, 1), (5, 1), (6, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (19, 1), (20, 1)], 5: [(1, 1), (2, 1), (4, 1), (6, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 6: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (14, 1), (17, 1), (18, 1), (19, 1)], 7: [(2, 1), (3, 1), (6, 1), (8, 1), (9, 1), (10, 1), (11, 1), (13, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 8: [(1, 1), (2, 1), (3, 1), (6, 1), (7, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (18, 1), (19, 1), (20, 1)], 9: [(1, 1), (2, 1), (6, 1), (7, 1), (8, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (16, 1), (18, 1), (19, 1)], 10: [(2, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (11, 1), (13, 1), (16, 1), (19, 1), (20, 1)], 11: [(2, 1), (3, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 12: [(2, 1), (4, 1), (5, 1), (8, 1), (9, 1), (14, 1), (15, 1), (17, 1), (18, 1), (20, 1)], 13: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (9, 1), (10, 1), (15, 1), (16, 1), (19, 1), (20, 1)], 14: [(1, 1), (3, 1), (4, 1), (5, 1), (6, 1), (9, 1), (12, 1), (15, 1), (16, 1), (18, 1), (19, 1), (20, 1)], 15: [(1, 1), (3, 1), (4, 1), (7, 1), (11, 1), (12, 1), (13, 1), (14, 1), (16, 1), (19, 1)], 16: [(1, 1), (3, 1), (4, 1), (5, 1), (7, 1), (9, 1), (10, 1), (11, 1), (13, 1), (14, 1), (15, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 17: [(1, 1), (4, 1), (5, 1), (6, 1), (7, 1), (11, 1), (12, 1), (16, 1), (19, 1), (20, 1)], 18: [(1, 1), (3, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (11, 1), (12, 1), (14, 1), (16, 1), (20, 1)], 19: [(2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1)], 20: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (16, 1), (17, 1), (18, 1)]})

Graph 8: defaultdict(<class 'list'>, {1: [(2, 1), (3, 1), (4, 1), (5, 1), (8, 1), (10, 1), (11, 1), (12, 1), (13, 1), (15, 1), (18, 1), (19, 1), (20, 1)], 2: [(1, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (12, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 3: [(1, 1), (2, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (13, 1), (14, 1), (15, 1), (16, 1), (18, 1), (19, 1), (20, 1)], 4: [(1, 1), (2, 1), (5, 1), (6, 1), (7, 1), (9, 1), (10, 1), (11, 1), (12, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 5: [(1, 1), (2, 1), (3, 1), (4, 1), (6, 1), (7, 1), (9, 1), (10, 1), (11, 1), (12, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 6: [(2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (18, 1), (19, 1), (20, 1)], 7: [(2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (9, 1), (11, 1), (12, 1), (14, 1), (15, 1), (16, 1), (18, 1), (19, 1), (20, 1)], 8: [(1, 1), (2, 1), (3, 1), (6, 1), (9, 1), (10, 1), (11, 1), (12, 1), (14, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 9: [(2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (19, 1), (20, 1)], 10: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (8, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 11: [(1, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (12, 1), (13, 1), (14, 1), (15, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 12: [(1, 1), (2, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (13, 1), (14, 1), (16, 1), (17, 1), (18, 1), (20, 1)], 13: [(1, 1), (3, 1), (6, 1), (9, 1), (10, 1), (11, 1), (12, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1)], 14: [(3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (15, 1), (17, 1), (18, 1), (20, 1)], 15: [(1, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (9, 1), (10, 1), (11, 1), (14, 1), (17, 1), (18, 1), (19, 1)], 16: [(2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (10, 1), (12, 1), (13, 1), (18, 1), (19, 1),

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Graph 9: defaultdict(<class 'list'>, {1: [(4, 1), (15, 1)], 2: [(8, 1), (16, 1), (18, 1), (20, 1), (23, 1), (24, 1), (30, 1)], 3: [(8, 1), (9, 1), (14, 1), (26, 1), (28, 1)], 4: [(1, 1), (5, 1), (7, 1), (10, 1), (12, 1), (13, 1), (17, 1)], 5: [(4, 1), (14, 1), (16, 1), (20, 1), (23, 1), (24, 1), (29, 1)], 6: [(10, 1), (14, 1), (17, 1), (20, 1), (22, 1), (24, 1), (27, 1), (29, 1)], 7: [(4, 1), (8, 1), (10, 1), (13, 1), (21, 1), (23, 1), (27, 1)], 8: [(2, 1), (3, 1), (7, 1), (9, 1), (10, 1), (11, 1), (12, 1), (15, 1), (20, 1), (27, 1)], 9: [(3, 1), (8, 1), (12, 1), (17, 1), (23, 1), (26, 1), (27, 1), (29, 1)], 10: [(4, 1), (6, 1), (7, 1), (8, 1), (12, 1), (17, 1), (18, 1), (21, 1), (24, 1), (30, 1)], 11: [(8, 1), (28, 1)], 12: [(4, 1), (8, 1), (9, 1), (10, 1), (14, 1), (20, 1), (25, 1)], 13: [(4, 1), (7, 1), (16, 1), (21, 1), (26, 1)], 14: [(3, 1), (5, 1), (6, 1), (12, 1), (15, 1), (18, 1), (19, 1)], 15: [(1, 1), (8, 1), (14, 1), (16, 1), (18, 1), (20, 1), (23, 1), (25, 1)], 16: [(2, 1), (5, 1), (13, 1), (15, 1), (29, 1), (30, 1)], 17: [(4, 1), (6, 1), (9, 1), (10, 1), (19, 1), (24, 1), (26, 1), (28, 1)], 18: [(2, 1), (10, 1), (14, 1), (15, 1), (20, 1)], 19: [(14, 1), (17, 1), (27, 1)], 20: [(2, 1), (5, 1), (6, 1), (8, 1), (12, 1), (15, 1), (18, 1), (29, 1)], 21: [(7, 1), (10, 1), (13, 1), (26, 1), (27, 1), (30, 1)], 22: [(6, 1), (26, 1), (27, 1), (30, 1)], 23: [(2, 1), (5, 1), (7, 1), (9, 1), (15, 1)], 24: [(2, 1), (5, 1), (6, 1), (10, 1), (17, 1), (29, 1)], 25: [(12, 1), (15, 1), (26, 1), (30, 1)], 26: [(3, 1), (9, 1), (13, 1), (17, 1), (21, 1), (22, 1), (25, 1), (30, 1)], 27: [(6, 1), (7, 1), (8, 1), (9, 1), (19, 1), (21, 1), (22, 1), (30, 1)], 28: [(3, 1), (11, 1), (17, 1), (29, 1)], 29: [(5, 1), (6, 1), (9, 1), (16, 1), (20, 1), (24, 1), (28, 1)], 30: [(2, 1), (10, 1), (16, 1), (21, 1), (22, 1), (25, 1), (26, 1), (27, 1)]})

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Graph 13: defaultdict(<class 'list'>, {1: [(3, 1), (14, 1), (18, 1), (19, 1), (22, 1), (29, 1), (33, 1), (35, 1), (40, 1)], 2: [(5, 1), (8, 1), (16, 1), (21, 1), (34, 1), (39, 1)], 3: [(1, 1), (7, 1), (29, 1), (31, 1), (35, 1)], 4: [(22, 1), (26, 1), (27, 1), (28, 1), (30, 1), (34, 1), (37, 1)], 5: [(2, 1), (7, 1), (14, 1), (15, 1), (24, 1), (27, 1), (31, 1), (36, 1)], 6: [(15, 1), (21, 1), (33, 1), (38, 1), (40, 1)], 7: [(3, 1), (5, 1), (11, 1), (12, 1), (17, 1), (20, 1), (22, 1), (24, 1), (32, 1)], 8: [(2, 1), (12, 1), (14, 1), (15, 1), (19, 1), (22, 1), (26, 1), (31, 1), (39, 1)], 9: [(11, 1), (14, 1), (17, 1), (29, 1), (32, 1), (34, 1), (35, 1), (39, 1)], 10: [(15, 1), (22, 1), (27, 1), (28, 1), (37, 1)], 11: [(7, 1), (9, 1), (16, 1), (20, 1), (27, 1), (31, 1), (36, 1), (38, 1)], 12: [(7, 1), (8, 1), (13, 1), (14, 1), (15, 1), (16, 1), (32, 1), (33, 1), (37, 1), (38, 1)], 13: [(12, 1), (19, 1), (24, 1), (25, 1), (30, 1), (40, 1)], 14: [(1, 1), (5, 1), (8, 1), (9, 1), (12, 1), (19, 1), (23, 1), (24, 1), (25, 1), (26, 1), (28, 1), (29, 1), (40, 1)], 15: [(5, 1), (6, 1), (8, 1), (10, 1), (12, 1), (22, 1), (28, 1), (33, 1), (40, 1)], 16: [(2, 1), (11, 1), (12, 1)], 17: [(7, 1), (9, 1), (20, 1), (27, 1), (28, 1), (30, 1), (31, 1), (37, 1)], 18: [(1, 1), (21, 1), (26, 1), (31, 1), (35, 1), (38, 1)], 19: [(1, 1), (8, 1), (13, 1), (14, 1), (26, 1), (34, 1)], 20: [(7, 1), (11, 1), (17, 1), (24, 1), (27, 1), (32, 1), (33, 1), (35, 1), (38, 1), (39, 1)], 21: [(2, 1), (6, 1), (18, 1), (24, 1), (31, 1), (33, 1)], 22: [(1, 1), (4, 1), (7, 1), (8, 1), (10, 1), (15, 1), (30, 1), (32, 1), (33, 1), (34, 1), (35, 1), (38, 1)], 23: [(14, 1), (26, 1), (32, 1), (36, 1), (37, 1), (38, 1), (40, 1)], 24: [(5, 1), (7, 1), (13, 1),

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Graph 14: defaultdict(<class 'list'>, {1: [(6, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (15, 1), (17, 1), (19, 1), (20, 1), (21, 1), (22, 1), (23, 1), (26, 1), (27, 1), (30, 1), (31, 1), (33, 1), (35, 1), (37, 1), (39, 1), (40, 1)], 2: [(13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1), (21, 1), (26, 1), (27, 1), (31, 1), (32, 1), (35, 1), (38, 1)], 3: [(4, 1), (6, 1), (8, 1), (11, 1), (12, 1), (13, 1), (17, 1), (24, 1), (25, 1), (26, 1), (27, 1), (29, 1), (30, 1), (34, 1)], 4: [(3, 1), (5, 1), (6, 1), (7, 1), (10, 1), (16, 1), (19, 1), (21, 1), (22, 1), (23, 1), (24, 1), (26, 1), (28, 1), (29, 1), (30, 1), (34, 1)], 5: [(4, 1), (7, 1), (8, 1), (9, 1), (12, 1), (13, 1), (17, 1), (20, 1), (24, 1), (25, 1), (28, 1), (29, 1), (31, 1), (32, 1), (34, 1), (35, 1), (37, 1), (38, 1)], 6: [(1, 1), (3, 1), (4, 1), (7, 1), (8, 1), (10, 1), (14, 1), (16, 1), (20, 1), (21, 1), (25, 1), (28, 1), (29, 1), (33, 1), (34, 1), (36, 1), (39, 1), (40, 1)], 7: [(4, 1), (5, 1), (6, 1), (8, 1), (11, 1), (12, 1), (16, 1), (20, 1), (27, 1), (29, 1), (32, 1), (35, 1), (37, 1), (38, 1), (39, 1)], 8: [(1, 1), (3, 1), (5, 1), (6, 1), (7, 1), (19, 1), (20, 1), (22, 1), (23, 1), (24, 1), (26, 1), (27, 1), (29, 1), (32, 1), (34, 1), (35, 1), (36, 1), (40, 1)], 9: [(1, 1), (5, 1), (10, 1), (11, 1), (12, 1), (13, 1), (19, 1), (23, 1), (25, 1), (26, 1), (27, 1), (31, 1), (36, 1), (38, 1), (39, 1)], 10: [(1, 1), (4, 1), (6, 1), (9, 1), (14, 1), (23, 1), (24, 1), (28, 1), (34, 1)], 11: [(1, 1), (3, 1), (7, 1), (9, 1), (13, 1), (16, 1), (17, 1), (21, 1), (22, 1), (24, 1), (25, 1), (26, 1), (29, 1), (31, 1), (33, 1), (34, 1), (36, 1), (38, 1), (39, 1), (40, 1)], 12: [(1, 1), (3, 1), (5, 1), (7, 1), (9, 1), (14, 1), (18, 1), (19, 1), (20, 1), (23, 1), (25, 1), (32, 1), (33, 1), (40, 1)], 13: [(1, 1), (2, 1), (3, 1), (5, 1), (9, 1), (11, 1), (14, 1), (15, 1), (17, 1), (21, 1), (24, 1), (26, 1), (30, 1), (31, 1), (36, 1), (37, 1), (39, 1), (40, 1)], 14: [(2, 1), (6, 1), (10, 1), (12, 1), (13, 1), (15, 1), (18, 1), (21, 1), (22, 1), (24, 1), (25, 1), (26, 1), (28, 1), (29, 1), (32, 1), (34, 1), (36, 1), (37, 1), (40, 1)], 15: [(1, 1), (2, 1), (13, 1), (14, 1), (20, 1), (23, 1), (28, 1), (31, 1), (33, 1), (35, 1), (37, 1), (38, 1), (40, 1)], 16: [(2, 1), (4, 1), (6, 1), (7, 1), (11, 1), (17, 1), (18, 1), (19, 1), (23, 1), (29, 1), (34, 1), (35, 1), (37, 1)], 17: [(1, 1), (2, 1), (3, 1), (5, 1), (11, 1), (13, 1), (16, 1), (20, 1), (21, 1), (22, 1), (24, 1), (25, 1), (26, 1), (37, 1)], 18: [(2, 1), (12, 1), (14, 1), (16, 1), (19, 1), (20, 1), (21, 1), (22, 1), (27, 1), (28, 1), (29, 1), (30, 1), (37, 1), (38, 1), (39, 1)], 19: [(1, 1), (2, 1), (4, 1), (8, 1), (9, 1), (12, 1), (16, 1), (18, 1), (20, 1), (23, 1), (24, 1), (25, 1), (26, 1), (27, 1), (32, 1), (33, 1), (36, 1), (37, 1)], 20: [(1, 1), (2, 1), (5, 1), (6, 1), (7, 1), (8, 1), (12, 1), (15, 1), (17, 1), (18, 1), (19, 1), (24, 1), (25, 1), (28, 1), (29, 1), (31, 1), (33, 1), (34, 1), (35, 1), (38, 1)], 21: [(1, 1), (2, 1), (4, 1), (6, 1), (11, 1), (13, 1), (14, 1), (17, 1), (18, 1), (24, 1), (25, 1), (26, 1), (32, 1), (36, 1), (39, 1), (40, 1)], 22: [(1, 1), (4, 1), (8, 1), (11, 1), (14, 1), (17, 1), (18, 1), (23, 1), (24, 1), (26, 1), (27, 1), (30, 1), (32, 1), (33, 1), (36, 1), (37,

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Graph 16: defaultdict(<class 'list'>, {1: [(2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (19, 1), (20, 1), (21, 1), (22, 1), (23, 1), (24, 1), (25, 1), (26, 1), (27, 1), (28, 1), (29, 1), (30, 1), (31, 1), (32, 1), (33, 1), (35, 1), (36, 1), (38, 1), (39, 1), (40, 1)], 2: [(1, 1), (3, 1), (4, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (12, 1), (13, 1), (16, 1), (17, 1), (20, 1), (21, 1), (22, 1), (23, 1), (24, 1), (25, 1), (27, 1), (28, 1), (30, 1), (31, 1), (32, 1), (33, 1), (34, 1), (35, 1), (36, 1), (37, 1), (39, 1)], 3: [(1, 1), (2, 1), (4, 1), (6, 1), (7, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (17, 1), (18, 1), (19, 1), (20, 1), (21, 1), (22, 1), (23, 1), (24, 1), (25, 1), (26, 1), (27, 1), (29, 1), (30, 1), (31, 1), (32, 1), (33, 1), (34, 1), (35, 1), (36, 1), (37, 1), (38, 1), (39, 1), (40, 1)], 4: [(1, 1), (2, 1), (3, 1), (5, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (17, 1), (18, 1), (21, 1), (22, 1), (24, 1), (25, 1), (26, 1), (27, 1), (28, 1), (29, 1), (31, 1), (32, 1), (33, 1), (34, 1), (35, 1), (36, 1), (37, 1), (38, 1), (39, 1), (40, 1)], 5: [(1, 1), (4, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (17, 1), (18, 1), (19, 1), (20, 1), (21, 1), (22, 1), (23, 1), (24, 1), (25, 1), (26, 1), (27, 1), (28, 1), (33, 1), (34, 1), (36, 1), (37, 1), (38, 1), (39, 1)], 6: [(1, 1), (2, 1), (3, 1), (8, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1), (21, 1), (23, 1), (24, 1), (25, 1), (27, 1), (28, 1), (29, 1), (30, 1), (31, 1), (32, 1), (33, 1), (34, 1), (35, 1), (37, 1), (38, 1), (39, 1)], 7: [(2, 1), (3, 1), (4, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (20, 1), (22, 1), (24, 1), (25, 1), (27, 1), (28, 1), (30, 1), (31, 1), (32, 1), (33, 1), (34, 1), (35, 1), (36, 1), (37, 1), (39, 1), (40, 1)], 8: [(1, 1), (2, 1), (4, 1), (5, 1), (6, 1), (7, 1), (9, 1), (10, 1), (11, 1), (13, 1), (17, 1), (18, 1), (19, 1), (20, 1), (21, 1), (22, 1), (23, 1), (24, 1), (25, 1), (26, 1), (27, 1), (29, 1), (30, 1), (32, 1), (33, 1), (34, 1), (35, 1), (36, 1), (37, 1), (38, 1), (40, 1)], 9: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (7, 1), (8, 1), (10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1), (22, 1), (23, 1), (24, 1), (25, 1), (26, 1), (27, 1), (28, 1), (30, 1), (31, 1), (33, 1), (34, 1), (37, 1), (38, 1), (39, 1), (40, 1)], 10: [(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (11, 1), (12, 1), (14, 1), (15, 1), (17, 1), (18, 1), (20, 1), (21, 1), (22, 1), (23, 1), (25, 1), (27, 1), (28, 1), (29, 1), (31, 1), (32, 1), (33, 1), (34, 1), (35, 1), (38, 1),

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List of the selected random nodes

From Graph 1: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

From Graph 2: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

From Graph 3: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

From Graph 4: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

From Graph 5: [1, 7, 10, 20, 6, 12, 8, 11, 15, 19]

From Graph 6: [5, 16, 7, 19, 1, 6, 3, 15, 12, 8]

From Graph 7: [18, 20, 14, 4, 1, 3, 11, 6, 17, 9]

From Graph 8: [8, 6, 14, 17, 5, 19, 16, 15, 9, 18]

From Graph 9: [25, 17, 9, 18, 15, 7, 11, 6, 24, 3]

From Graph 10: [11, 5, 10, 30, 15, 13, 8, 18, 16, 3]

From Graph 11: [21, 18, 23, 25, 24, 6, 5, 27, 28, 22]

From Graph 12: [25, 23, 20, 27, 4, 19, 5, 18, 17, 28]

From Graph 13: [10, 3, 35, 34, 17, 19, 31, 36, 32, 9]

From Graph 14: [26, 12, 15, 16, 29, 37, 14, 3, 4, 10]

From Graph 15: [24, 6, 20, 16, 38, 39, 8, 29, 7, 18]

From Graph 16: [39, 14, 29, 20, 12, 31, 19, 1, 25, 17]