Lancaster University
Leipzig

BSc Part 2 (Second Year) Examinations 2024/25

School of Computing and Communications

LZSCC.223   Algorithms   Mock Exam

Time allowed: **60** minutes (ONE hour)

Instructions to Candidates

- There are 3 pages with 3 parts, 10 questions, and 40 possible points in total.

- Questions are not ordered by difficulty.

- Answer all questions.

- Clearly mark your final answer (e.g. cross out rough works etc.). If there are multiple potential answers, you get **0 points** for that task.

- When answering individual parts of a question, clearly indicate which part you are referring to, e.g. by writing the number.

- Unless otherwise noted, **always** provide a brief justification for your answer. Answers without justification do not yield points, even if correct.

- Where relevant, each question clearly indicates which programming language is being referred to.

- You can always refer to line numbers of given code in your answers.

Further Remarks

- You may assume that $\mathbf{P} \neq \mathbf{NP}$.

Part 1: Knowledge   Total Points: 20

QUESTION 1.A   [2 Points]

Draw a weighted graph that has vertices s and t, 5 vertices in total, and the maximum flow from s to t equals 10. Briefly explain why your graph has these properties.

QUESTION 1.B   [4 Points]

Suppose that two algorithms A and B solve the same problem dealing with graphs. Algorithm A has an asymptotic runtime of $\mathcal{O}(n \cdot m)$, and algorithm B has a runtime of $\mathcal{O}(m + n \log n)$, where n is the number of vertices and m the number of edges. Which algorithm would you prefer? Why?

QUESTION 1.C   [2 Points]

Suppose that algorithm A solves an algorithmic problem X and A has an asymptotic runtime of $\mathcal{O}(2^{n!})$. Does this necessarily imply that the problem X is undecidable?

QUESTION 1.D   [4 Points]

Explain one advantage and one disadvantage when comparing Dijkstra's algorithm to Bellman-Ford.

QUESTION 1.E   [4 Points]

Which problem is solved by the *Raycasting* algorithm? Describe one case where a new ray needs to be chosen.

QUESTION 1.F   [4 Points]
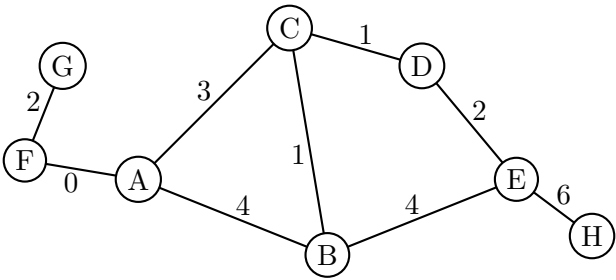
What are the two key operations in a UnionFind data structure? Explain what they are used for.

Part 2: Application   Total Points: 10

Consider the above graph. Give the solution to the SSSP problem as computed by *Dijkstra's algorithm* starting from *A*. You do not need to provide the shortest paths, just the distances.

Item	A	B	C	D	E
Value	10	5	3	6	1
Weight	5	3	1	4	1

- Consider the above set of items. Determine the optimal solution (both value and items) to the   3P
  0/1-Knapsack problem with a capacity of 7.

- What is the complexity class of this problem? Describe an efficient approach to tackle it.   2P

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
"bn"	"dj"	"e"	"iys"	"jy"	"k"	"m"	"n"	"ow"	"pr"	"pyb"	"re"	"vl"	"wf"	"z"	"ztk"

Give the indices that *binary search* checks when searching for the string `'h'` in the above sorted array. The used comparison is the *lexicographic* ordering (the standard of Python).

Part 3: Problem Solving   Total Points: 10

Similar to coursework tasks, not included in the mock exam.