St. Francis Xavier University
Department of Computer Science

CSCI 355: Algorithm Design and Analysis
Midterm Examination
February 15, 2024
1:30pm–2:20pm

Student Name: ____________________

Email Address: ____________________

Instructor: T. J. Smith (Section 20)

Format:

The midterm is fifty minutes long. The midterm consists of 4 questions worth a total of 25 marks. The midterm booklet contains 6 pages, including the cover page and one blank page at the back of the midterm booklet for rough work.

Reference Materials:

None.

Instructions:

1. Write your name and email address in the spaces above.
2. Answer each question either in the space provided or on a blank page. If you use a blank page to write your answer, indicate this clearly in the space provided for the question. Show all of your work.
3. Ensure that your midterm booklet contains 6 pages. Do not detach any pages from your midterm booklet.
4. Do not use any unauthorized reference materials or devices during this midterm.
5. Sign in the space below. Your signature indicates that you understand and agree to these instructions and the university's examination policies.

Signature: ____________________

Question	Marks	Score
1	5	
2	5	
3	6	
4	9	
Total	25	

Multiple Choice

[5 marks] 1. For each of the following questions, select exactly one answer by circling the associated letter. Incorrect answers will not be penalized. Answers with more than one letter circled will be marked as incorrect.

(a) Consider the following matching, where current matches are denoted in bold:

	1st	2nd	3rd
StFX	**Andy**	Kim	David
Dal	Kim	Andy	**David**
CBU	Andy	**Kim**	David

	1st	2nd	3rd
Andy	Dal	**StFX**	CBU
Kim	StFX	Dal	**CBU**
David	StFX	**Dal**	CBU

Which of the following pairs is unstable?

A. Dal–Andy
B. StFX–Kim
C. Dal–David
D. None of the above.

(b) What does it mean for a function $f(n)$ to be Big-O of another function $g(n)$?

A. For all large-enough values of n, some constant times $f(n)$ is bounded below by $g(n)$.
B. We can replace $g(n)$ with $f(n)$ in any expression to produce an equivalent expression.
C. For all large-enough values of n, $f(n)$ is bounded above by some constant times $g(n)$.
D. The function $f(n)$ is always larger than the function $g(n)$.

(c) Suppose we have the coin denominations $\{1, 5, 10, 25, 100, 200\}$ in cents, and we need to produce change in the amount of $5.64. What coins will the greedy cashier's algorithm return?

A. 1×4, 5×2, 25×2, 100×5
B. 1×4, 10×1, 25×2, 100×1, 200×2
C. 1×4, 10×1, 25×6, 200×2
D. 1×4, 10×6, 100×1, 200×2

(d) Given the following two statements about the MST greedy algorithm, fill in the blanks appropriately.

1. The **red rule** takes a __________ with no red edges, selects an uncoloured edge of __________, and colours it red.
2. The **blue rule** takes a __________ with no blue edges, selects an uncoloured edge of __________, and colours it blue.

A. 1. cycle/min cost
   2. cutset/max cost
B. 1. cutset/min cost
   2. cycle/max cost
C. 1. cycle/max cost
   2. cutset/min cost
D. 1. cutset/max cost
   2. cycle/min cost

(e) Which of the following MST algorithms adapts well to parallelization?

A. Prim's algorithm
B. Kruskal's algorithm
C. Reverse-delete algorithm
D. Borůvka's algorithm

Short Answer

[5 marks] 2. Consider the following pseudocode. State the runtime of this algorithm in terms of Big-O notation, assuming n is the input size. Also give a brief (2–3 sentence) justification of your answer.

You can assume that assignments and arithmetic operations take $O(1)$ time. Note that you should give the tightest upper bound possible as your answer.

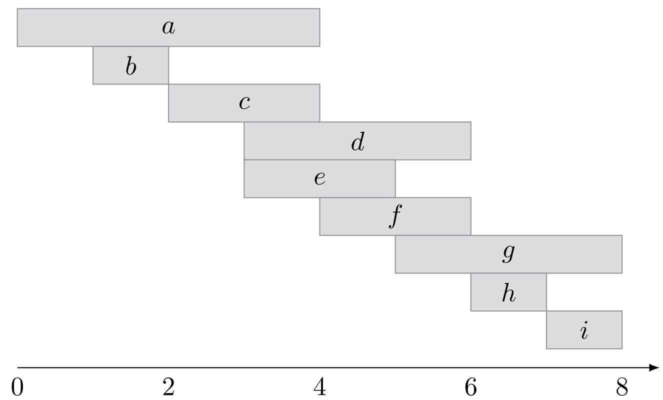
Algorithm: Mystery algorithm

```
s ← 1
for 1 ≤ i ≤ n do
    s ← s × 2
    for 1 ≤ j ≤ s do
        t ← t + 1
return t
```

[6 marks] 3. (a) Which of the following heuristics is optimal for the interval scheduling problem?

- ◯ Earliest start time first
- ◯ Earliest finish time first
- ◯ Shortest interval
- ◯ Longest interval

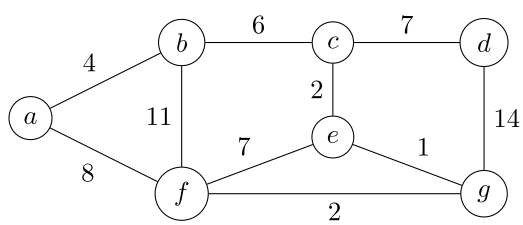
(b) Using the optimal heuristic from part (a) on the following instance of the interval scheduling problem, find a maximum subset of mutually compatible jobs.



[9 marks] 4. (a) Explain briefly how *Dijkstra's algorithm* computes shortest paths in a graph.

(b) Using any appropriate algorithm, find a minimum spanning tree for the following graph.

Specify which algorithm you are using. You do not need to draw every step performed by the algorithm; you only need to give the sequence of vertices or edges added by the algorithm. For clarity, draw your final minimum spanning tree on the graph as well.



This blank page may be used for rough work.