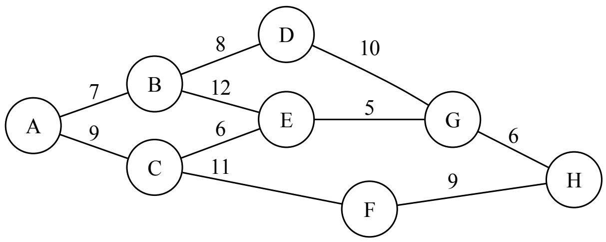
Name: Solution Guide **CCID:** ____________

CMPUT 355 Quiz #2 **15 marks** **50 minutes** **closed-book** **no devices**

1. [5 points] Consider the following search graph. Edges are labelled with costs, and the table beneath gives the heuristic value for each node. The goal is to find a path from A to H. Recall that a node is *expanded* when it is removed from the fringe. List the order in which nodes are expanded by A*, and contents of the fringe after each expansion. When two nodes have identical priorities, expand the one that comes alphabetically first (i.e., break ties in alphabetical order).



n	A	B	C	D	E	F	G	H
$h(n)$	20	17	15	12	10	9	6	0

Node	**Fringe**
Expand A	B:24, C:24
Expand B	C:24, D:27, E:29
Expand C	D:27, E:25, F:29
Expand E	D:27, F:29, G:26
Expand G	D:27, F:29, H:26
Expand H (done)	D:27, F:29

2. [4 points] Consider the following 6×6 sliding tile position:

	3	2	1	5	4
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	35	34

(a) How many *inversions* does this position have? 5 inversions: $(3,2),(3,1),(2,1)$ are out of order, but $1,2,3$ are correctly ordered with respect to all later numbers; $(5,4)$ are out of order, but correctly ordered with respect to all other numbers; $(35,34)$ are out of order, but correctly ordered with respect to all earlier numbers.

(b) How many *misplaced tiles* does this position have? 33 misplaced tiles: 35 and 5 are correctly placed; every other tile is misplaced.

(c) What is the *taxicab distance* for this position?
1 needs to travel 3 left; 2 needs to travel 1 left; 3 needs to travel 1 right. 4 needs to travel 2 left. 5 is correctly placed. 6,12,18,24,30 need to travel 1 up and 5 right. 7–11,13–17,19–23,25–29, 31–33 need to travel 1 left. 35 is correctly placed; 34 needs to travel 2 left.
3+1+1+2+5(6)+23(1)+2 = **62**.

(d) Is this position *solvable*? Why or why not? Yes; there are an even number of columns, and there are an odd number of inversions and the blank height is odd. Equivalently, (number of inversions + blank height) is even.

3. [4 points] Suppose that running breadth-first search on a 8×3 sliding tile puzzle takes 0.5s in the worst case.

   (a) How many possible 8×3 positions are there? (You don't need to expand the expression to get an actual number)
   24!

   (b) What is the average degree (i.e., number of neighbours) of a 8×3 position?

2	3	2
3	4	3
3	4	3
3	4	3
3	4	3
3	4	3
3	4	3
2	3	2

   4/24 corners have 2 neighbours; 14/24 edges have 3 neighbours; 6/24 central cells have 4 neighbours.

$$\frac{4}{24}2 + \frac{14}{24}3 + \frac{6}{24}4 = \frac{74}{24} = \frac{37}{12}.$$

   (c) What is the average degree (i.e., number of neighbours) of a 4×6 position?

2	3	3	3	3	2
3	4	4	4	4	3
3	4	4	4	4	3
2	3	3	3	3	2

   4/24 corners have 2 neighbours; 12/24 edges have 3 neighbours; 8/24 central cells have 4 neighbours.

$$\frac{4}{24}2 + \frac{12}{24}3 + \frac{8}{24}4 = \frac{76}{24} = \frac{19}{6}.$$

   (d) Give an estimate of how long it would take to run breadth-first search on an unsolvable 4×6 position. Justify your answer. $0.5s \times \frac{24!76}{24!74} = \frac{38}{74}s$

4. [2 points] Recall that `stile/15puzzle.py` has three different subgoal schedules:

   (i) `[[1],[2],[3,4],[5],[6],[7,8],[9,13],[10,14],[11,12,15]]`

   (ii) `[[1,2],[3,4],[5,6,7,8],[9,10,11,12,13,14,15]]`

   (iii) `[[1,2,3,4],[5,9,13],[6,7,8,10,11,12,14,15]]`

   schedule (i) places tile $\{1\}$ first, then tile $\{2\}$, etc. Schedule (ii) places tiles $\{1, 2\}$ first, then tiles $\{3, 4\}$; Suppose that we run `stile/15puzzle.py` on a solvable position.

   (a) Which schedule is likely to produce the *shortest solution*? Why?
   Schedule (iii), because it has a small number of large subgoals.

   (b) Which schedule is likely to *search the fewest nodes*? Why?
   Schedule (i), because each subgoal is very small (and will therefore have a very small search space).