6.034 Quiz 1

28 September 2018

Name	SOLUTIONS
Email	

For 1 extra credit point: Circle the TA whose recitations you attend so that we can more easily enter your score in our records and return your quiz to you promptly.

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Problem number	Maximum	Score	Grader
1 - Search	34		
2 - Games	32		
3 - Rules	34		
Total	100		

There are 12 pages in this quiz, including this one, but not including tear-off sheets. Tear-off sheets with duplicate drawings and data are located after the final page of the quiz.

As always, open book, open notes, open just about everything, including a calculator, but no computers.

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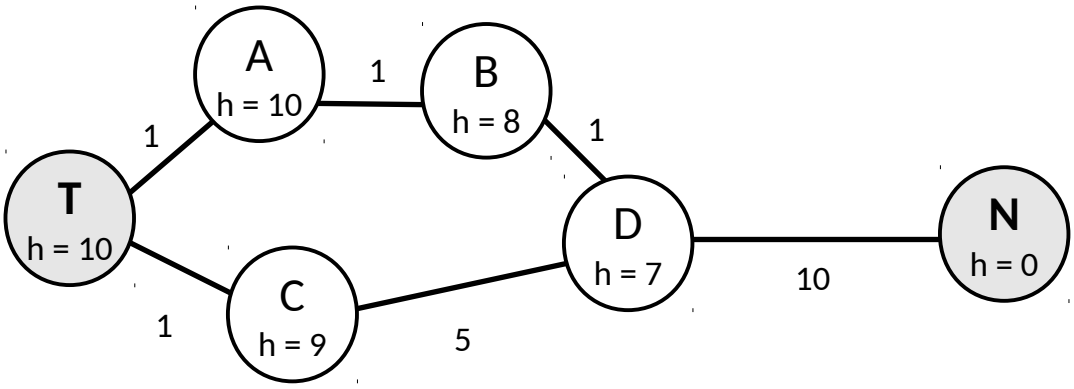
Problem 1: Search (34 points)

Part A: Getting to Nidavellir (12 points)

Thanos is looking for the Soul Stone to complete his rock collection. He has gotten a lead from Ronan the Accuser that the Soul Stone is on planet Nidavellir. Thanos pulls up his map of the universe to try to figure out how to get from his current location (T) to Nidavellir (N).

For your convenience, a copy of the graph is provided on a tear-off sheet at the end of the quiz.

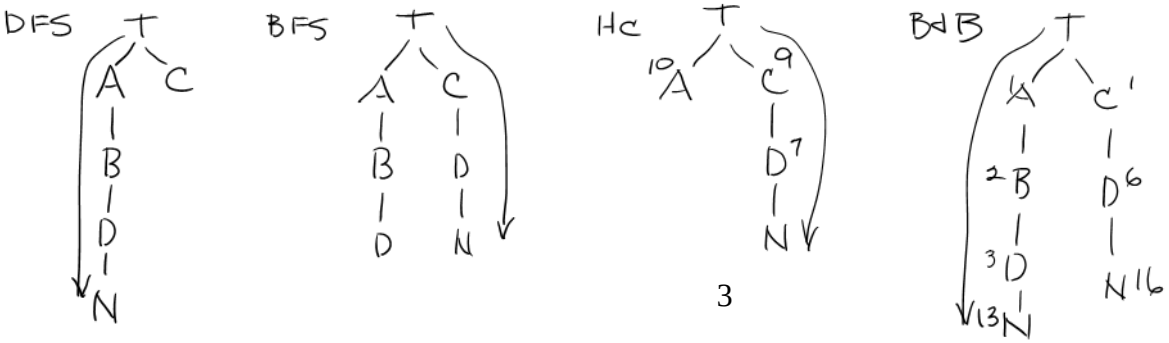
On the map below, each location is a node labeled with a letter and a heuristic distance to the goal (N). Each link is labeled with its length, i.e., the distance between nodes. The start node (T) and goal node (N) are gray.



Thanos (T) has two paths to get to Nidavellir (N): T-A-B-D-N and T-C-D-N. In order to choose his path, Thanos tries several different search algorithms. Circle which of the two paths is generated first by each of the following search algorithms.

NOTE: Break ties alphabetically.

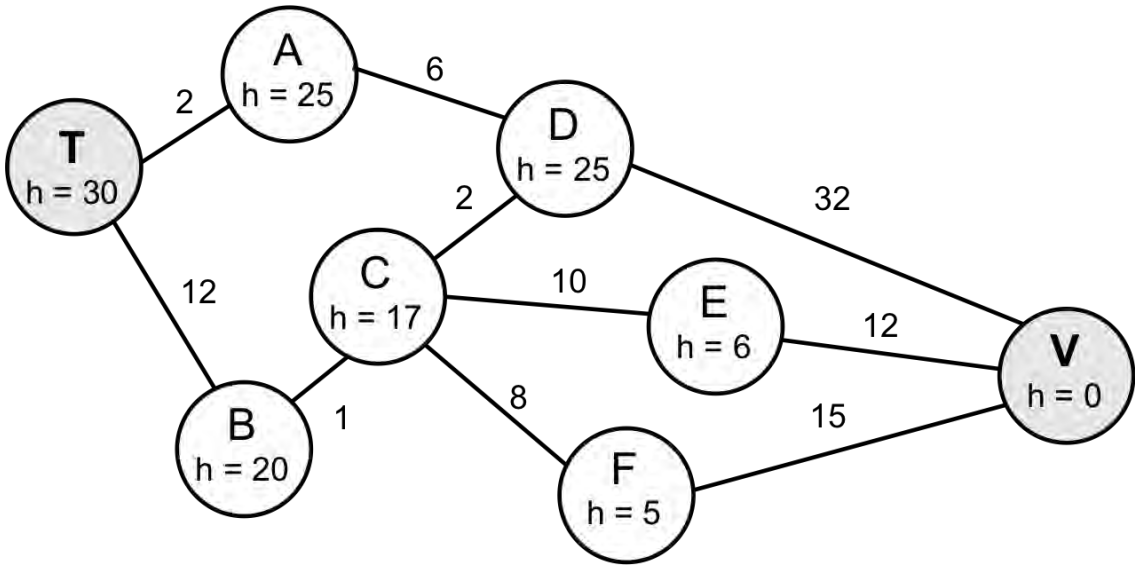
Depth-first search (with backtracking):	**T-A-B-D-N**	**T-C-D-N**
Breadth-first search:	**T-A-B-D-N**	**T-C-D-N**
Hill climbing (with no backtracking):	**T-A-B-D-N**	**T-C-D-N**
Branch and bound (no heuristic or extended set):	**T-A-B-D-N**	**T-C-D-N**



Part B: On to Vormir! (22 points)

Much to Thanos's disappointment, the Soul Stone wasn't on Nidavellir. Luckily for Thanos, he learns from Gamora that the Soul Stone is located on planet Vormir, which is in a different galaxy. Thanos pulls up a more complete map of the universe.

For your convenience, a copy of the graph is provided on a tear-off sheet after the last page of the quiz.

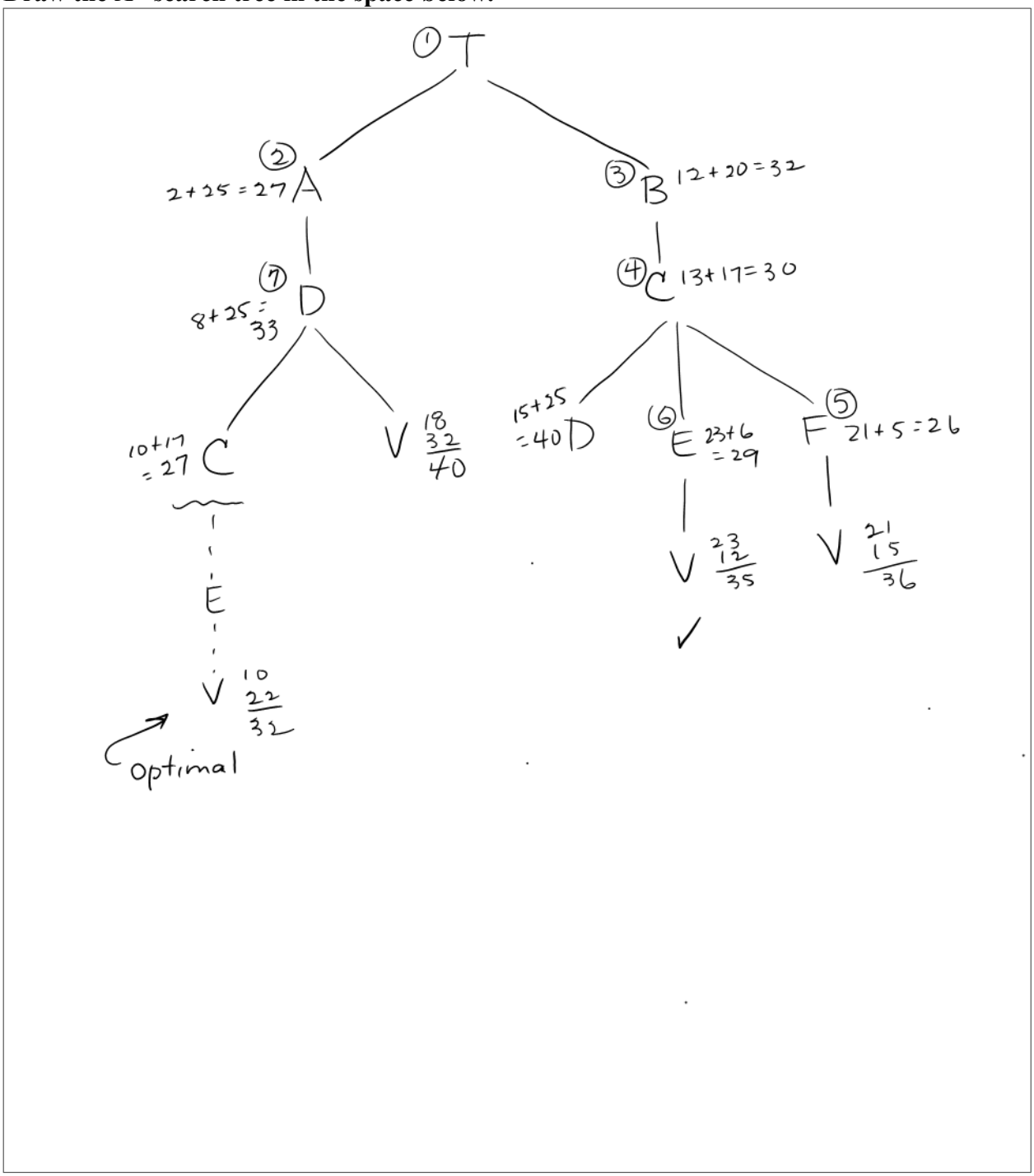


B1 (16 points) This time Thanos uses A* (<u>with heuristic and extended set</u>) to find a path from his location (T) to Vormir (V).

In the space below, draw Thanos's search tree.

- Draw the children of each node in alphabetical order (e.g., A < B < C).
- Break any ties using alphabetical order of the <u>entire path</u> (e.g., S-K-Y < S-P-A).
- Clearly indicate the order in which you extended nodes by numbering the extended nodes in your search tree (①, ②, ③, ...).

Draw the A* search tree in the space below.



B2 (3 points) What is the final path that Thanos finds using A*?

T-B-C-E-V

B3 (3 points) Is this path optimal? (Circle one.) **YES** **NO**

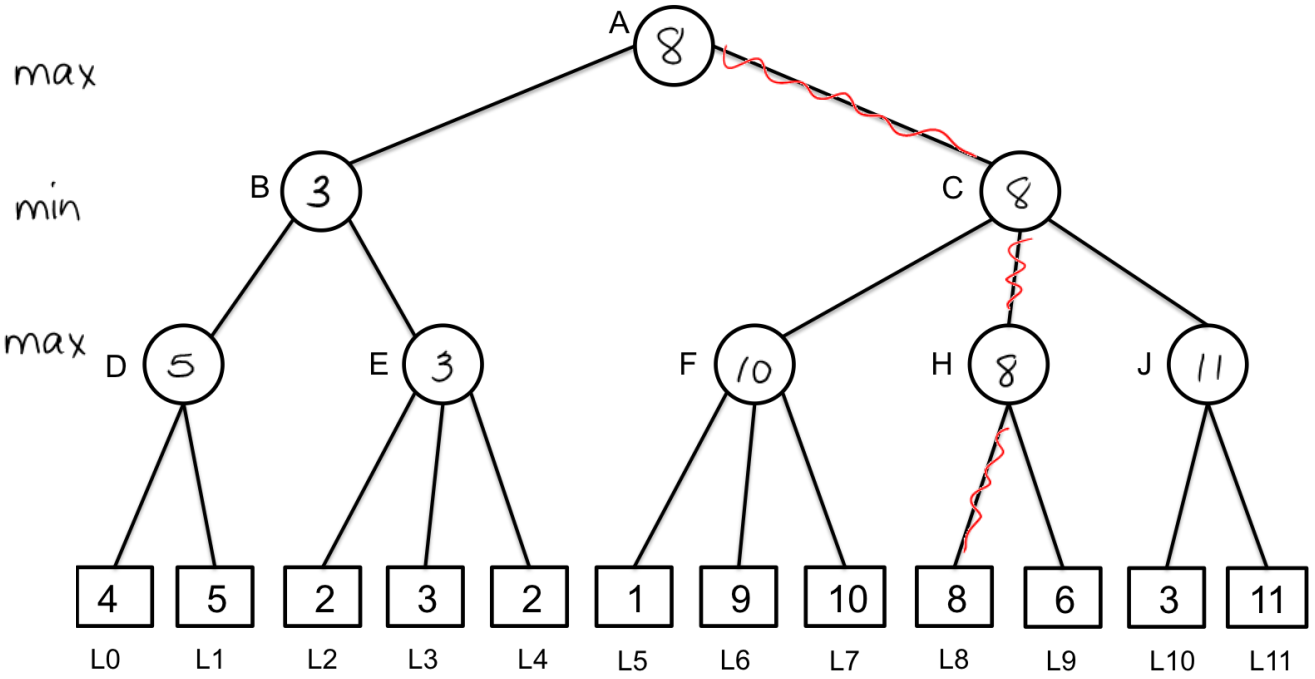
Problem 2: Games in the Boardroom (32 points)

Samsung and Apple are neck-and-neck battling for smartphone dominance. Samsung has a team of 6.034 experts who vow to use their keen business acumen to help Samsung maximize its 2019 sales.

Part A: A Minimax Lesson (12 points)

You think the Minimax algorithm will help in Samsung's decision making, and you decide to give your boss a Minimax lesson. You use the example below, which represents game play between two players, KiNam and Tim. **KiNam moves first and is trying to maximize the value at the top decision node; Tim moves second and is trying to minimize the value.**

A1 (8 points) Perform Minimax (without alpha-beta pruning) on the tree, and write each decision node's value inside the node, using the static evaluation values given by the tree's leaf nodes (L0 - L11).



A2 (1 points) What is the value at the top node (A)?

8

A3 (3 points) What Minimax path produces the value at the top node (A)?

A - C - H - L8

Part B: Minimax and Phones (20 points)

You're now ready to help Samsung maximize its 2019 smartphone sales. Suppose that exactly 1 billion phones will be sold and that no other companies compete in this market, i.e., every sale made by Samsung is a missed sale for Apple, and vice versa.

Samsung has two decisions to make: whether its new Nebula 2 will sport a large or small screen, and whether its marketing will be focused in Japan or the US. Samsung's decision will be influenced by Apple's choice of screen size for its iPhone XX's screen. Economic forecasts predict Samsung will sell the following numbers of phones given the two companies' choices.

For your convenience, a copy of the table is provided on a tear-off sheet at the end of the quiz.

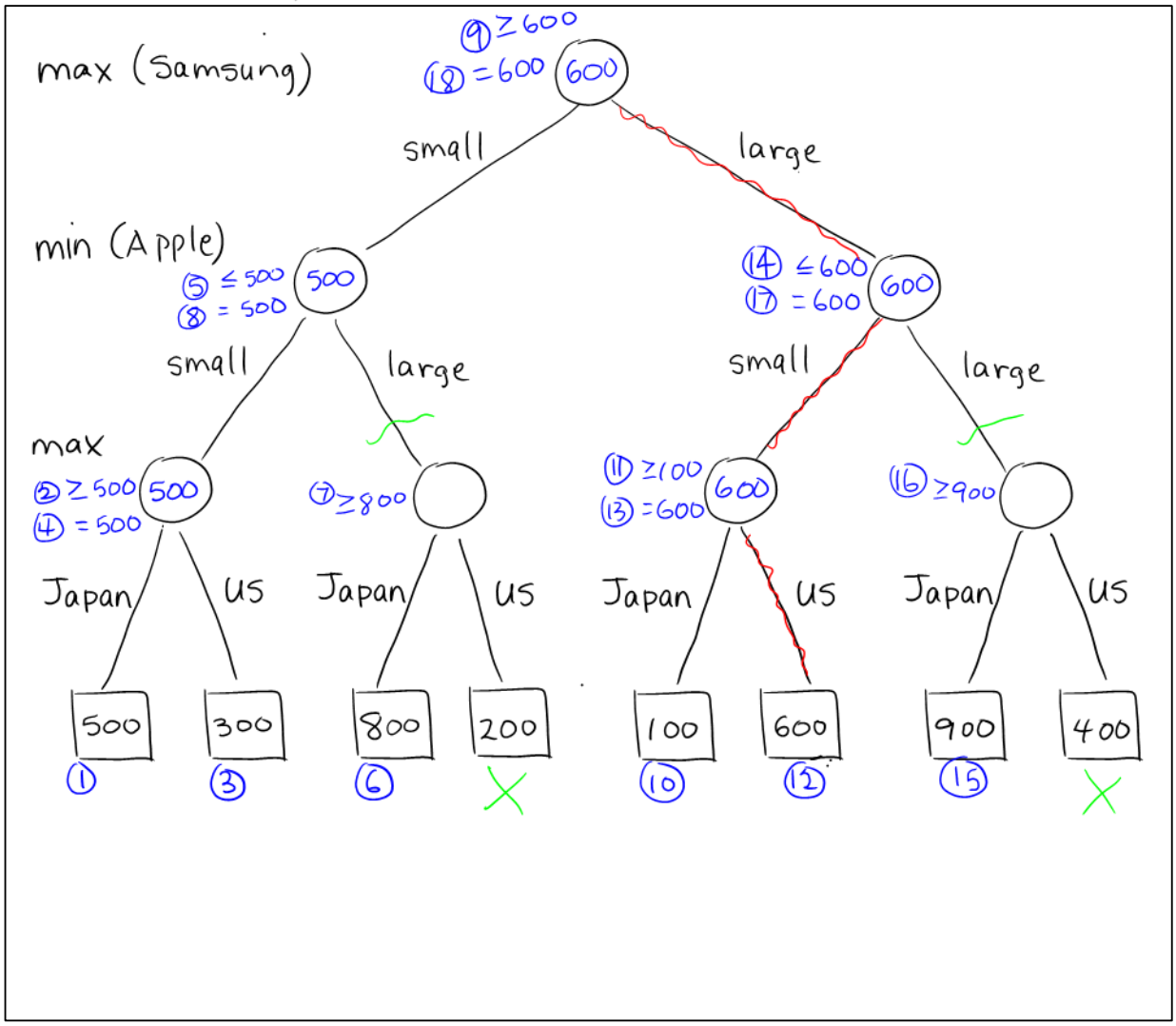
Phones sold by Samsung in 2019, forecast			Apple	
			Small Screen	Large Screen
SAMSUNG	Small Screen	Japan	500	800
		US	300	200
	Large Screen	Japan	100	900
		US	600	400

Note: All numbers are in millions of phones.

You find out that Samsung can choose its marketing location **after** Apple decides on its iPhone XX screen size. You want to help **Samsung maximize sales** by using a Minimax algorithm, and you suggest the following order of decision making, knowing that **Apple will attempt to minimize Samsung sales**: Samsung chooses screen size, Apple chooses screen size, then Samsung chooses marketing location.

B1 (6 points) On the next page draw the game tree corresponding to your suggested order of decision making. Assume when drawing decision nodes in a layer that **the state resulting from a choice of small screen is to the left of a choice of large screen, and that a state resulting from a choice of Japan is to the left of a choice of the US**. Between nodes, label the links with the decision choices.

Draw your game tree here.



B2 (10 points) To come up with recommendations for Samsung screen size and marketing location, fill in values at decision nodes in your tree by performing Minimax with alpha-beta pruning. Indicate which leaf nodes are not statically evaluated by placing an "X" beneath the nodes. Indicate which branches are pruned by drawing a zigzag line across the branches.

B3 (1 point) What size of Samsung screen do you recommend? (Circle one.) **Small** **Large**

B4 (1 point) Where do you suggest Samsung market its phones? (Circle one.) **Japan** **US**

B5 (2 points) According to your recommendation using the forecast sales figures, how many phones will Samsung sell?

600×10^6

Problem 3: Rules (34 points)

Frank Gehry, the architect who designed the Stata Center, emailed MIT President Reif warning him that if MIT wants to throw an end-of-year graduation party at Stata, someone should first find out if the building is still in good condition. Gehry suspects that the building may have long-standing problems that the construction company, Skanska, has failed to fix. President Reif employs 6.034 students to build a rule-based system to determine Stata's condition.

Below are the students' rules and assertions.

For your convenience, a copy of the rules and assertions is provided on a tear-off sheet at the end of the quiz.

Rules:

P0	**IF OR**('**(?x)** was partying', '**(?x)** made deficient drawings') **THEN** ('**(?x)** breached contract', '**(?x)** was negligent')
P1	**IF AND**('**(?x)** miscalculated loads', '**(?x)** forgot expansion-control joints') **THEN** '**(?x)** breached contract'
P2	**IF** '**(?x)** was negligent' **THEN** '**(?x)** miscalculated loads'
P3	**IF AND**('**(?x)** breached contract', '**(?y)** cannot hold more people') **THEN** '**(?y)** may fall'
P4	**IF AND**('**(?x)** miscalculated loads', **OR** ('**(?x)** says **(?y)** wasn't strength-tested' **(?x)** says it's **(?y)**'s design')) **THEN** ('**(?y)** cannot hold more people')

Assertions:

A0: Skanska forgot expansion-control joints

A1: Gehry was partying

A2: Skanska was negligent

A3: Gehry says Stata wasn't strength-tested

A4: Skanska says it's Stata's design

Part A: Backward Chaining (14 points)

Using the rules and assertions provided, perform backward chaining starting from the hypothesis: `'Stata may fall'`

- In the table below, write all the hypotheses that the backward chainer checks, in the order they are checked. (The first line has been filled out for you, and the table has more lines than you need.)
- You can show your work for partial credit: Use the space on the next page to draw the goal tree that would be created by backward chaining starting from this hypothesis.

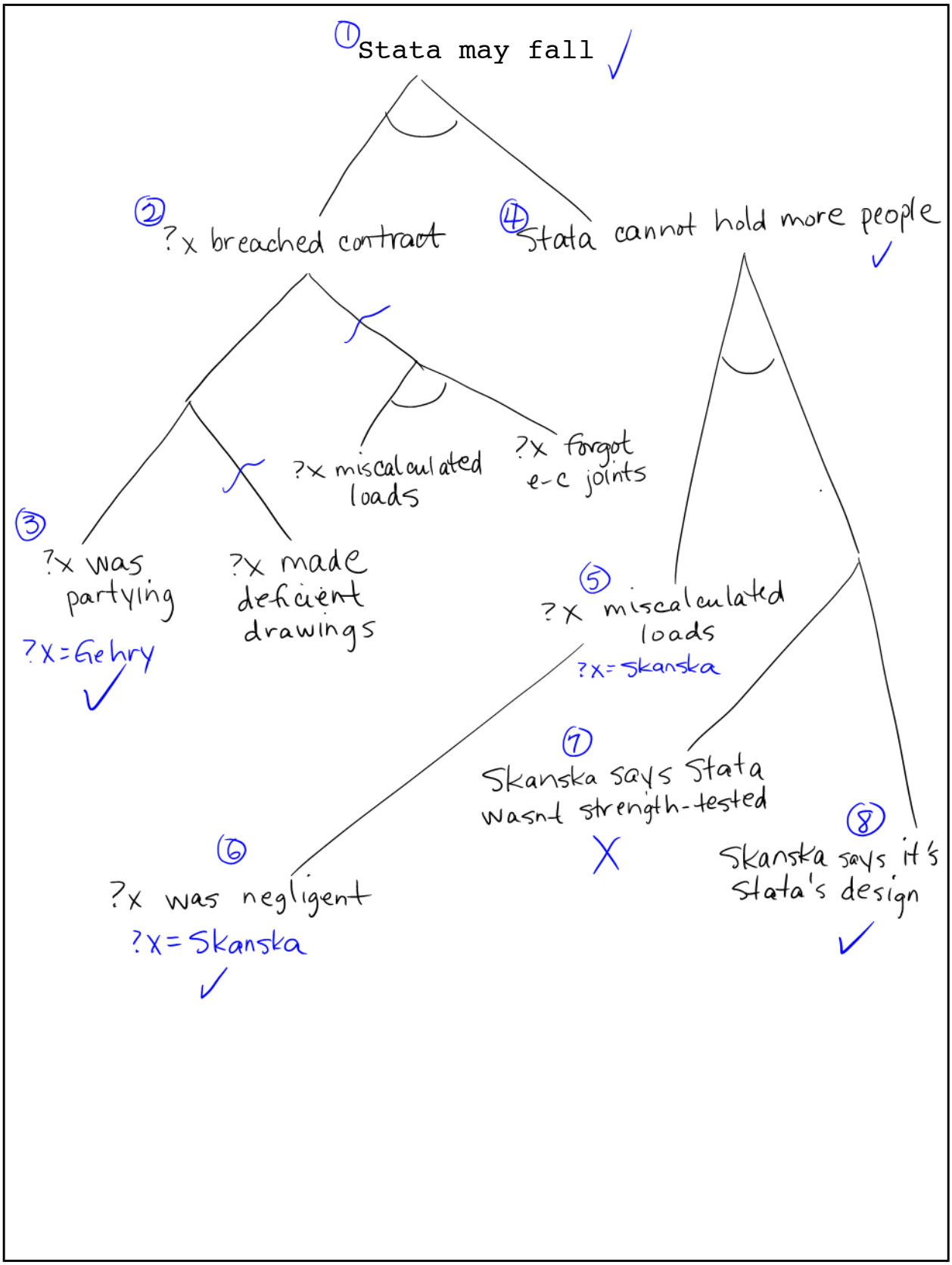
Make the following assumptions about backward chaining:

- Rules are tried in the order they appear on the previous page (and on the tear-off sheet).
- Antecedents are tried in the order they appear in a rule.
- Short circuiting (aka lazy evaluation) is in effect.
- The backward chainer never alters the list of assertions.
- The backward chainer tries to find a matching assertion in the list of assertions. If no matching assertion is found, it tries to find a rule with a matching consequent. When no matching consequents are found, it concludes that the hypothesis is false.

Hypotheses checked in backward chaining *Note: Feel free to abbreviate lengthy words.*

1.	Stata may fall
2.	?x breached contract
3.	?x was partying
4.	Stata cannot hold more people
5.	?x miscalculated loads
6.	?x was negligent
7.	Skanska says Stata wasn't strength-tested
8.	Skanska says it's Stata's design
9.	
10.	
11.	

Draw goal tree here for possible partial credit. *Note: Feel free to abbreviate lengthy words.*



Part B: Forward Chaining (20 points)

Using the rules and assertions provided, fill in the table below by performing forward chaining. There are more rows than you need, and some parts of the table have been filled out for you.

- For each iteration, list: the rules whose antecedents match the assertions, the rule that fires, the binding(s) for the fired rule, and any new assertion(s) added.
- If no rules match or fire, or no new assertions are generated, write NONE in the corresponding box.

Make the following assumptions about forward chaining:

- When multiple rules match, rule-ordering determines which rule fires.
- New assertions are added to the bottom of the list of assertions.
- If a particular rule matches in more than one way, the matches are considered in the top-to-bottom order of the matched assertions. So if a particular rule has an antecedent that matches both A1 and A2, the match with A1 is considered first.

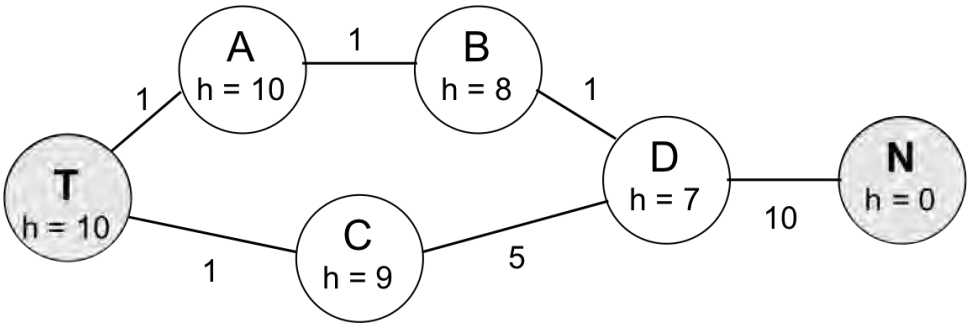
Note: Feel free to abbreviate lengthy words.

Step	Matched	Fired	Rule Instance Bindings	New Assertion(s) Added
1	P0, P2	P0	?x = Gehry	A5: Gehry breached contract A6: Gehry was negligent
2	P0, P2	P2	?x = Skanska	A7: Skanska miscalculated loads
3	P0, P1, P2, P4	P1	?x = Skanska	A8: Skanska breached contract
4	P0, P1, P2, P4	P2	?x = Gehry	A9: Gehry miscalculated loads
5	P0, P1, P2, P4	P4	?x = Skanska ?y = Stata	A10: Stata cannot hold more people
6	P0, P1, P2, P3, P4	P3	?x = Gehry ?y = Stata	A11: Stata may fall
7	P0, P1, P2, P3, P4	NONE	NONE	NONE
8				
9				

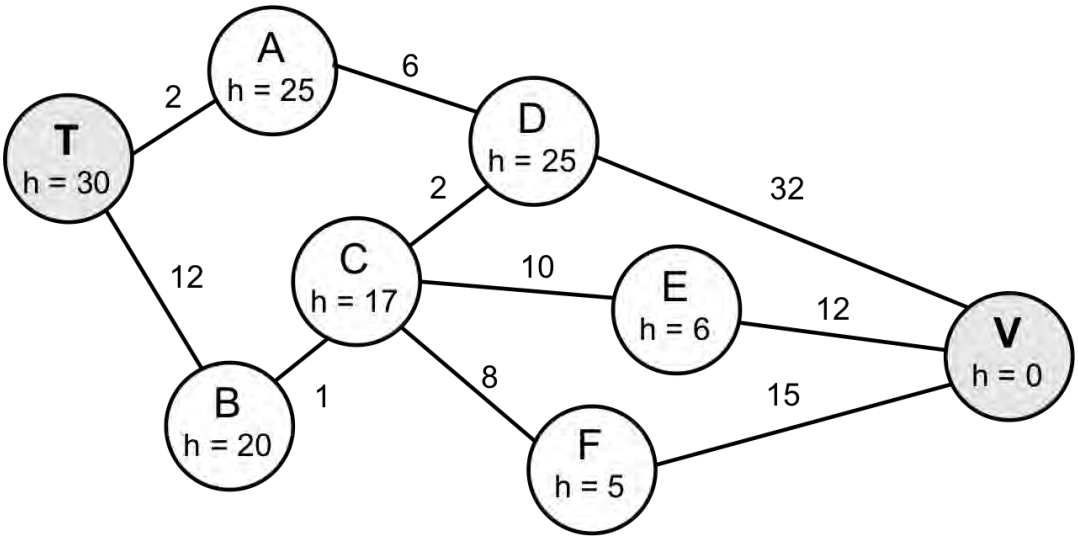
Tear-off sheet

Graphs for Problem 1 (Search)

Part A



Part B



Tear-off sheet

Table for Problem 2 (Games)

Phones sold by Samsung in 2019, forecast			Apple	
			Small Screen	Large Screen
SAMSUNG	Small Screen	Japan	500	800
		US	300	200
	Large Screen	Japan	100	900
		US	600	400

Note: All numbers are in millions of phones.

Tear-off sheet

Rules and Assertions for Problem 3 (Rules)

Rules:

P0	**IF OR**(‘**(?x)** was partying’, ‘**(?x)** made deficient drawings’) **THEN** (‘**(?x)** breached contract’, ’**(?x)** was negligent’)
P1	**IF AND**(‘**(?x)** miscalculated loads’, ‘**(?x)** forgot expansion-control joints’) **THEN** ‘**(?x)** breached contract’
P2	**IF** ‘**(?x)** was negligent’ **THEN** ‘**(?x)** miscalculated loads’
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Assertions:

A0: Skanska forgot expansion-control joints

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