6.034 Quiz 1

25 September 2019

Name	
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.

Sydney Gibson	**Rui Li**	**Allison Tam**
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Damon Jones	**Mira Partha**	

Problem number	Maximum	Score	Grader
1 - Search	33		
2 - Rules	34		
3 - Games	33		
Total	100		

There are 16 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, the quiz is open book, open notes, open just about everything, including a calculator, but no computers or cell phones.

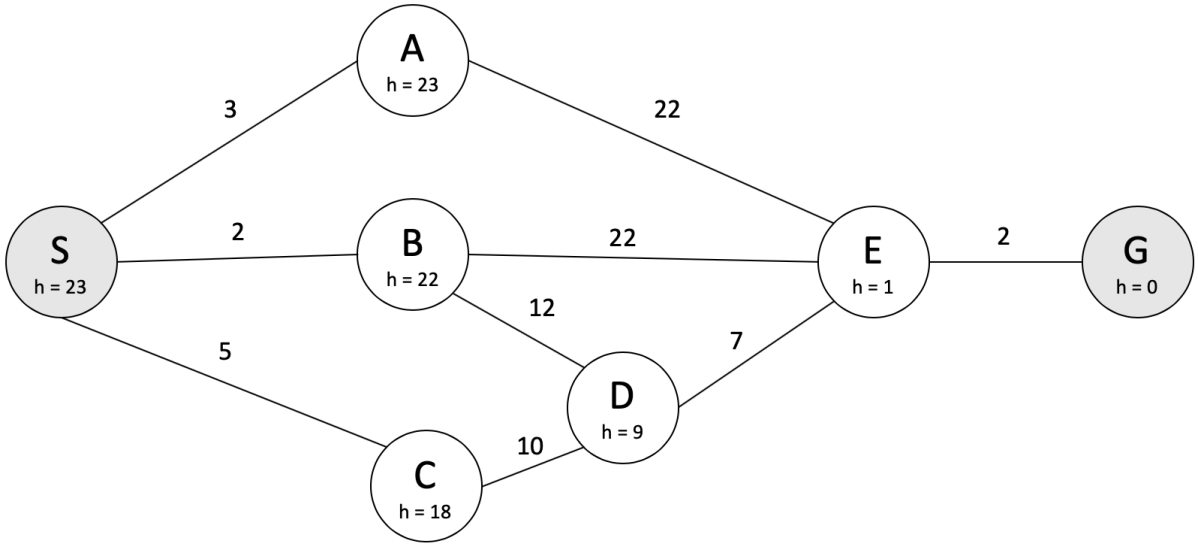
Problem 1: Search (33 points)

Part A: Finding Love in a Hopeless Place (16 points)

Colton, a single bachelor searching for the love of his life, has just received news that his soulmate, Cassie, is waiting for him. He doesn't remember, however, how to get to her. He must figure out how to reach her.

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

In the graph below, Colton is currently at node S, while Cassie is at node G. Each location is a node labeled with a letter and a heuristic distance to the goal (G). Each edge is labeled with its length, i.e., the distance between nodes. The start node (S) and goal node (G) are gray.



A1 (1 point) What is the shortest path, in terms of distance, from the start node S to the goal node G? (You may solve this problem by inspection.) Break any ties using alphabetical order of the entire path (e.g., S-A-E < S-B-E).

Write the shortest path, including S and G.

A2 (10 points) Colton uses **branch and bound** (with extended set and no heuristic) to find a path from node S to node G. In the space below, draw the search tree. Be sure to

a. Draw the children of each node in alphabetical order.
b. Break any ties using alphabetical order of the entire path (e.g., S-A-E < S-B-E).
c. Clearly indicate the order in which you extended nodes by numbering the extended nodes in your search tree (①, ②, ③, ...).

For full credit, draw your search tree in this box.

A3 (2 points) List the nodes in the extended set, in the order extended.

A4 (2 points) Which path did Colton find using branch and bound?

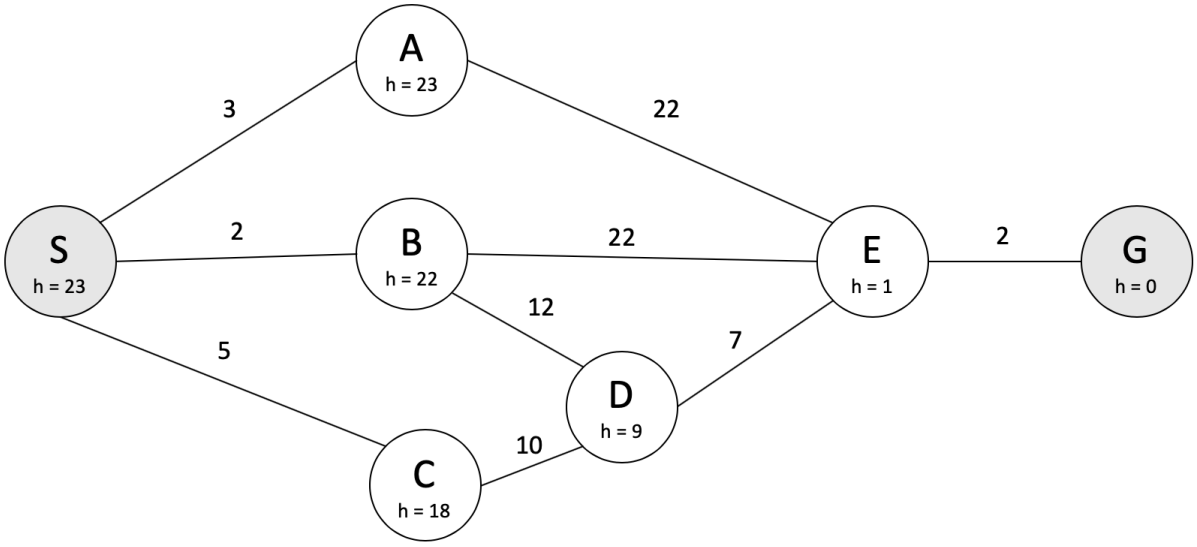
A5 (1 points) Is the path optimal? (Circe one.) **YES** **NO** **CAN'T TELL**

Part B: Love Ain't Easy (17 points)

After talking to some of his fellow bachelors, Colton hears that there may be a better path to Cassie. This time Colten attempts to get from node S to node G using **A* search** (with heuristic and extended set).

For your convenience, the graph from part A is repeated below and provided on a tear-off sheet at the end of the quiz.

Each location is a node labeled with a letter and a heuristic distance to the goal (G). Each edge is labeled with its length, i.e., the distance between nodes. The start node (S) and goal node (G) are gray.



B1 (11 points) On the next page, draw the A* search tree. Be sure to:

a. Draw the children of each node in alphabetical order (e.g., A < B < C).
b. Break any ties using alphabetical order of the entire path (e.g., S-A-E < S-B-E).
c. Clearly indicate the order in which you extended nodes by numbering the extended nodes in your search tree (①, ②, ③, …)

For full credit, draw your search tree in this box.

B2 (2 points) List the nodes in the extended set, in the order extended.

B3 (1 point) Is the path optimal? (Circle one.) **YES** **NO** **CAN'T TELL**

B4 (3 points) Which of the nodes below are **not admissible** according to the heuristic? Circle **all** that apply.

Node A **Node B** **Node C** **Node E** **NONE of these**

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Problem 2: Wizard of Rules (34 points)

Your roommates have been listening to the soundtrack from the hit musical WICKED constantly since the start of the semester. Unfortunately they've never seen the musical in person and are missing some important details. You decide to use your 6.034 skills to help them fill in the gaps in their musical knowledge.

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

Rules:

P0	**IF** **OR**(**AND**('**(?x)** loathes **(?y)**', '**(?x)** can do magic') '**(?x)** is popular') **THEN** '**(?x)** meets The Wizard'
P1	**IF** **OR**('**(?x)** is green', '**(?x)** is popular') **THEN** '**(?x)** can do magic'
P2	**IF** **OR**('**(?x)** and **(?y)** are roommates' **AND**('**(?x)** is green', '**(?y)** dances through life')) **THEN** '**(?x)** loathes **(?y)**')
P3	**IF** **AND**('**(?x)** is blonde', '**(?y)** loathes **(?x)**') **THEN** '**(?x)** is popular'
P4	**IF** **AND**('**(?x)** is evil', '**(?y)** meets **(?x)**', **NOT**('**(?y)** is wicked')) **THEN** '**(?y)** becomes The Good Witch'
P5	**IF** **AND**('**(?x)** lives in Oz', '**(?y)** meets **(?x)**', **NOT**('**(?y)** becomes The Good Witch')) **THEN** ('**(?x)** is evil', '**(?y)** is wicked')

Assertions:

A0: Elphaba is green
A1: Glinda is blonde
A2: The Wizard lives in Oz
A3: Elphaba and Glinda are roommates

Part A: Backward Chaining (16 points)

Help your roommate by starting with the hypothesis:

`Glinda can do magic`

A1 (12 points) Perform backward chaining using the rules and assertions on the previous page. In the table on the next page, list all the hypotheses checked **in the order that the hypotheses are checked** (note there may be more lines than you need). For partial credit, draw the goal tree below.

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 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.

For partial credit, draw your search tree in this box.

`Glinda can do magic`

H1. *Glinda can do magic*
H2.
H3.
H4.
H5.
H6.
H7.
H8.
H9.

During backward chaining:

A2 (1 point) How many hypotheses were checked? ☐

A3 (1 point) Did you short circuit? (Circle one.)

YES **NO** **CAN'T TELL**

A4 (1 point) Does the system produce "`Glinda can do magic`"?

YES **NO** **CAN'T TELL**

A5 (1 point) Did you backtrack?

YES **NO** **CAN'T TELL**

Part B: Forward Chaining (18 points)

Suppose one of your roommates wants to know even more details about Elphaba and Glinda's life in Oz. She asks you to use forward chaining to find out everything we learn **until we get the assertion**:

`The Wizard is evil`

B1 (15 points) Perform forward chaining and fill out the table on the next page.

For each iteration, list:

- the rules whose antecedents match the assertions
- the rule that fires
- the binding(s) for the fired rule
- 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 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.

Step	Matched	Fired	Rule Instance Bindings	New Assertion(s) Added
1	*P1, P2*	*P1*	*x=Elphaba*	*A4: Elphaba can do magic*
2				
3				
4				
5				
6				
7				
8				
9				

During forward chaining:

B2 (2 points) Are the following assertions produced? (Circle TRUE or FALSE.)

Elphaba becomes The Good Witch **TRUE** **FALSE**

Elphaba hates Glinda **TRUE** **FALSE**

B3 (1 point) According to our forward chaining algorithm, would the rule system produce new assertions after producing "`The Wizard is evil`"? (Circle one.)

YES **NO** **CAN'T TELL**

Problem 3: Game of Courses (33 points)

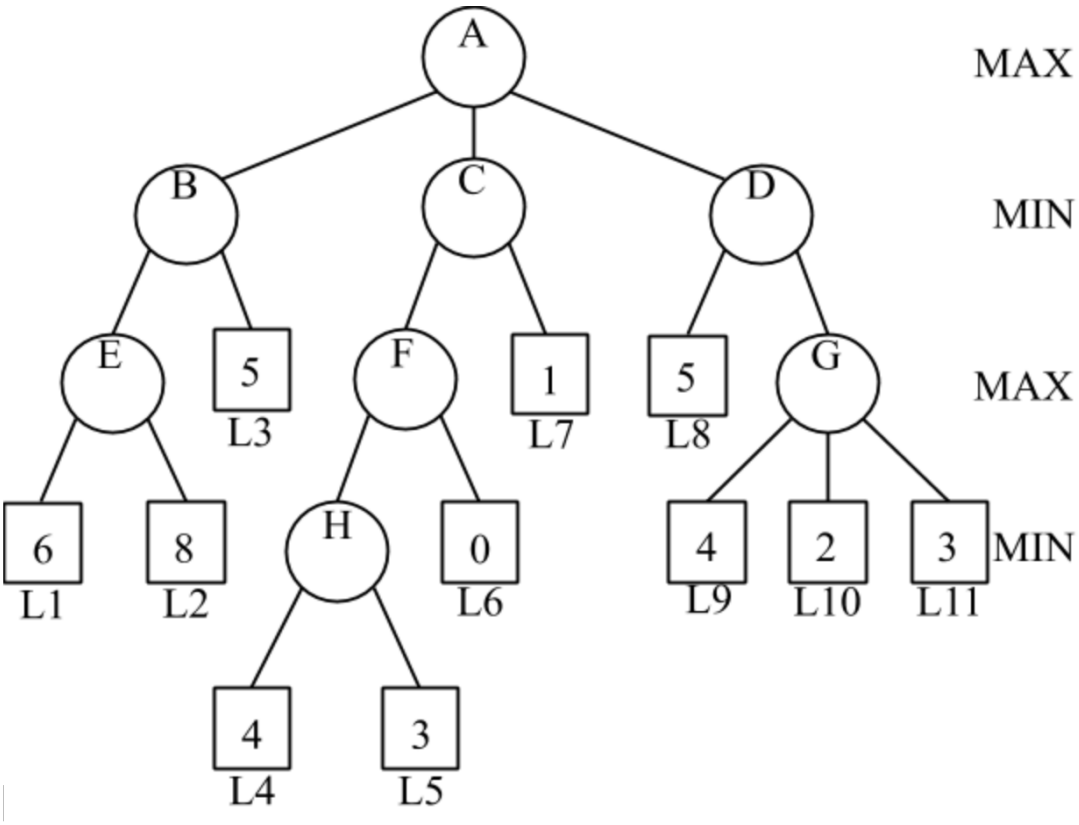
Part A: A Minimax Take-Over (12 points)

You read that Anne Hunter has announced her retirement as the perpetual Course 6 (EECS) Overlord. As a parting gift, she has announced that she will take over another MIT department by merging it with Course 6.

To help her decide which department to take over, she plans to use the Minimax algorithm on the search tree below, which represents the negotiation process as a game tree.

Each **decision node** in the tree is displayed as a labeled circle. Each **leaf node**, labeled with department designations L1 through L11, is displayed as a square. The static evaluation at each leaf node represents the amount of additional funding (in millions of dollars) that Course 6 would receive if Overlord Hunter took over that department.

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



Overlord Hunter aims to **maximize** additional funding for her department and gets to make the first decision. Her opposition seeks to **minimize** the funding.

A1 (8 points) Perform Minimax (without alpha-beta pruning) on the **tree on the previous page**, using the static evaluation values given by the tree's leaf nodes (L1 - L11). **Write each decision node's value inside the node**,

A2 (1 point) What is the Minimax value at node A?

A3 (1 point) Which leaf node does the Minimax algorithm choose? (Circle your answer.)

L1 **L2** **L3** **L4** **L5** **L6** **L7** **L8** **L9** **L10** **L11**

A4 (2 points) What is the Minimax path? Write the node labels in order.

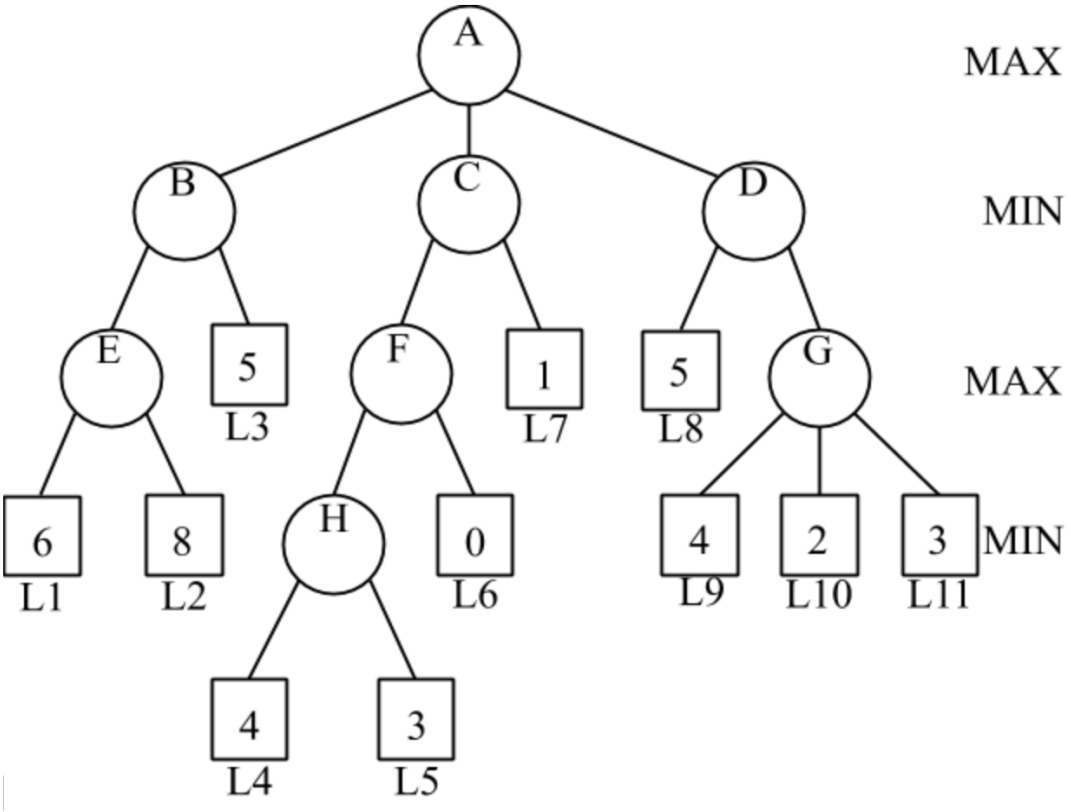
Part B: Cut to the chase (17 points)

Overlord Hunter wants to speed up the decision-making process by **pruning the search tree.**

B1 (13 points) Perform Minimax search with alpha-beta pruning on the tree below, which is a copy of the tree from Part A.

a. Indicate on the tree below which leaf nodes are pruned, i.e., **not** evaluated, by placing an "X" beneath the nodes.

b. Indicate which branches are pruned by drawing a zigzag line across the branches.



B1 (1 point) Which leaf nodes are pruned, i.e., not evaluated? (Circle **all** that apply. If no leaf nodes are pruned, circle NONE.)

L1 L2 L3 L4 L5 L6 L7 L8 L9 L10 L11 NONE

B2 (1 point) Which decision nodes are pruned, i.e., not assigned values? (Circle **all** that apply. If no decision nodes are pruned, circle NONE.)

A B C D E F H G NONE

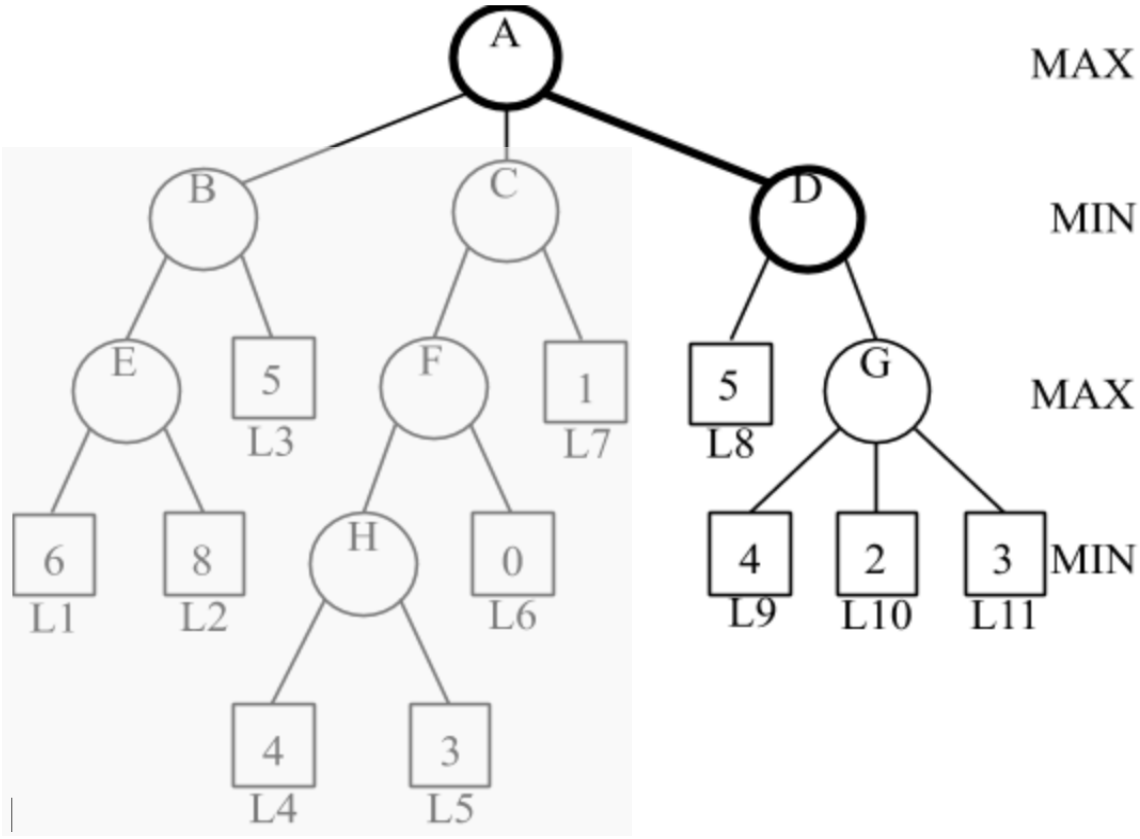
B3 (2 points) Could reordering the branches of the above tree increase the number of nodes that do not need to be evaluated during alpha-beta pruning? (Circle one.)

YES NO CAN'T TELL

Part C: Clever arguing (4 points)

Despite the Overloard's best efforts, she seems to be losing influence over the course of the negotiations. She **restructures her plan** hoping to salvage the remainder of her influence.

She decides to force the decision down the right sub-branch of the tree, along the partial path highlighted below (from node A to node D).



C1 (3 points) Perform Minimax (without alpha-beta pruning) on the right sub-branch. What is the Minimax value at node A?

C2 (1 point) Which leaf node does the Minimax algorithm choose? (Circle your answer.)

L1 L2 L3 L4 L5 L6 L7 L8 L9 L10 L11

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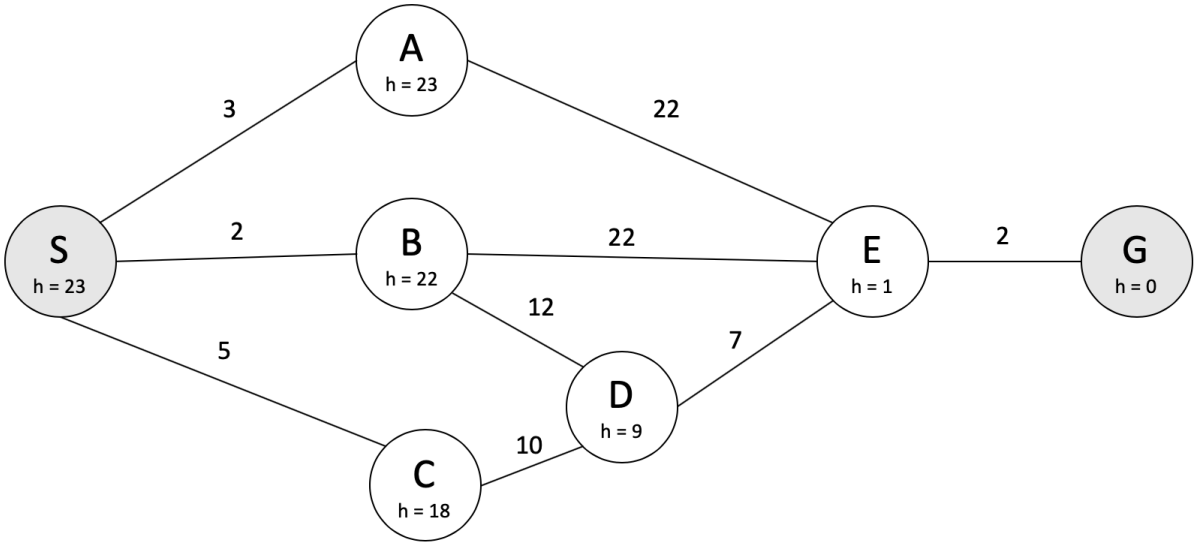
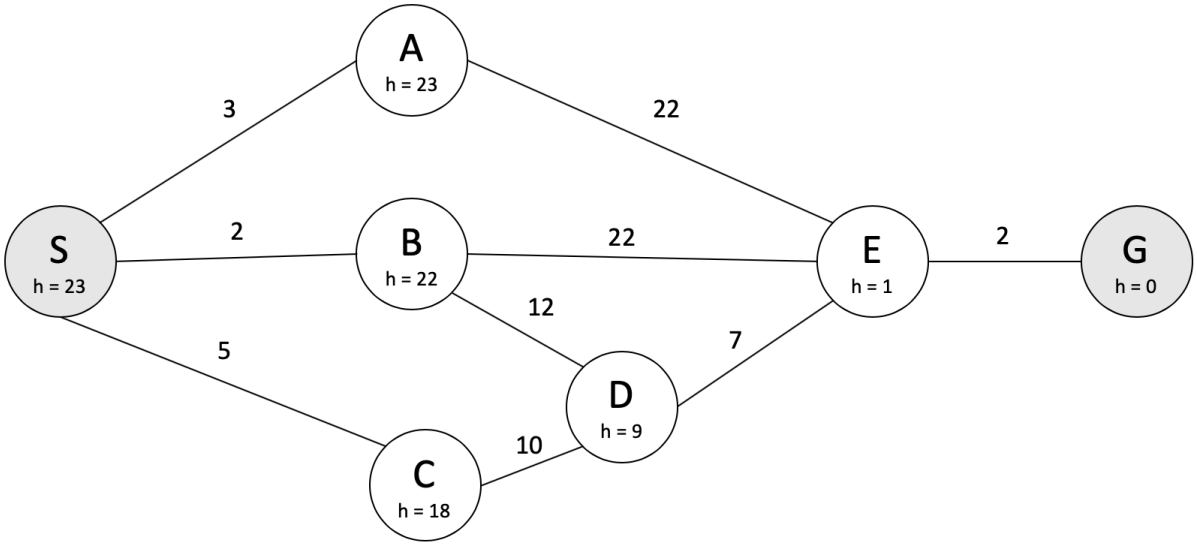
Tear-off sheet

We do not collect tear-off sheets, so please show your work on the quiz pages, not the tear-off sheet.

Graph for Problem 1 (Search)

Parts A and B





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Rules and Assertions for Problem 2 (Rules)

Rules:

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P1	**IF OR**(‘**(?x)** is green’, ‘**(?x)** is popular’) **THEN** ‘**(?x)** can do magic’
P2	**IF OR**(‘**(?x)** and **(?y)** are roommates’ **AND**(‘**(?x)** is green’, ‘**(?y)** dances through life’)) **THEN** ‘**(?x)** loathes **(?y)**’)
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Assertions:

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Tear-off sheet

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Tree for Problem 3 (Games)

Parts A and B