6.034 Practice 1 v2

28 September 2020

Name	
Email	

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

There are 15 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.

The quiz is open book, open notes, open just about everything, including a calculator, but no internet or other people

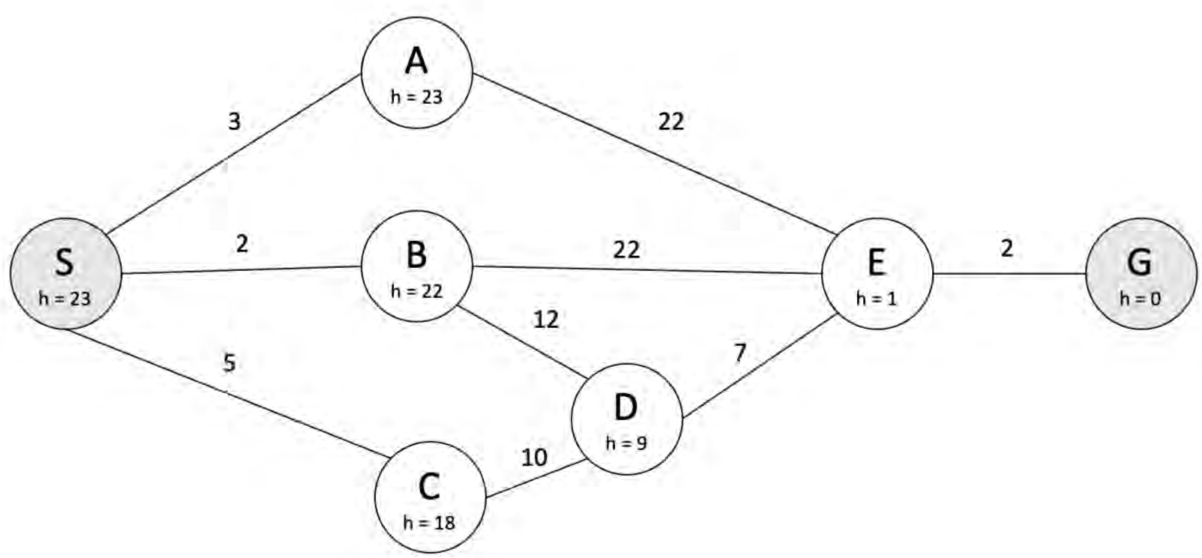
Problem 1: Search (33 points)

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 as a separate download.

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?

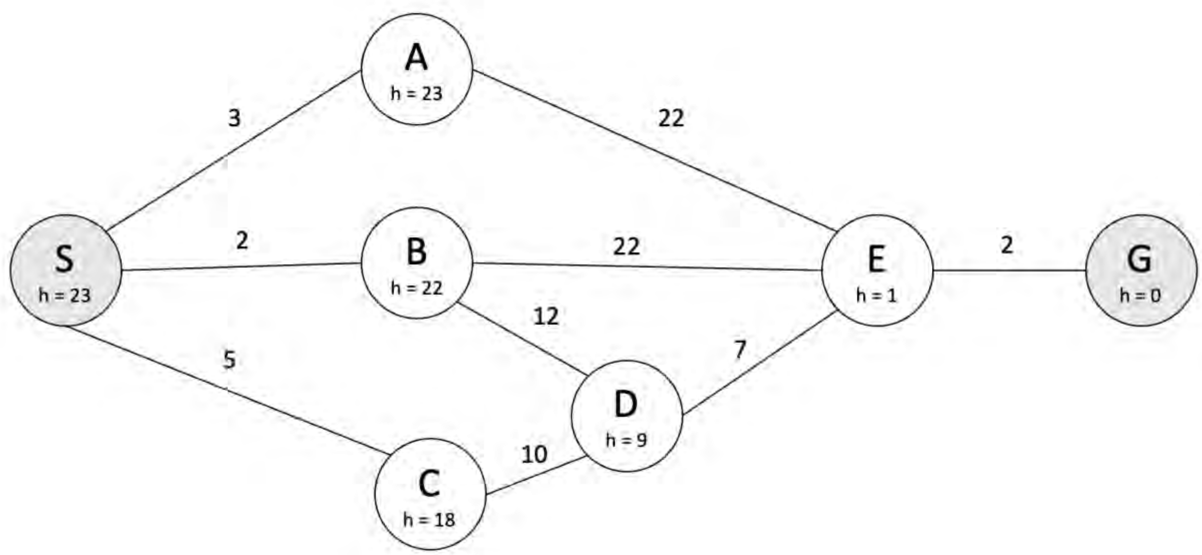
A5 (1 points) Is the path optimal? (Circe one.) **YES** **NO** **CAN'T TELL**

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** (<u>with heuristic and extended set</u>).

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**

Problem 2: Game of Courses (33 points)

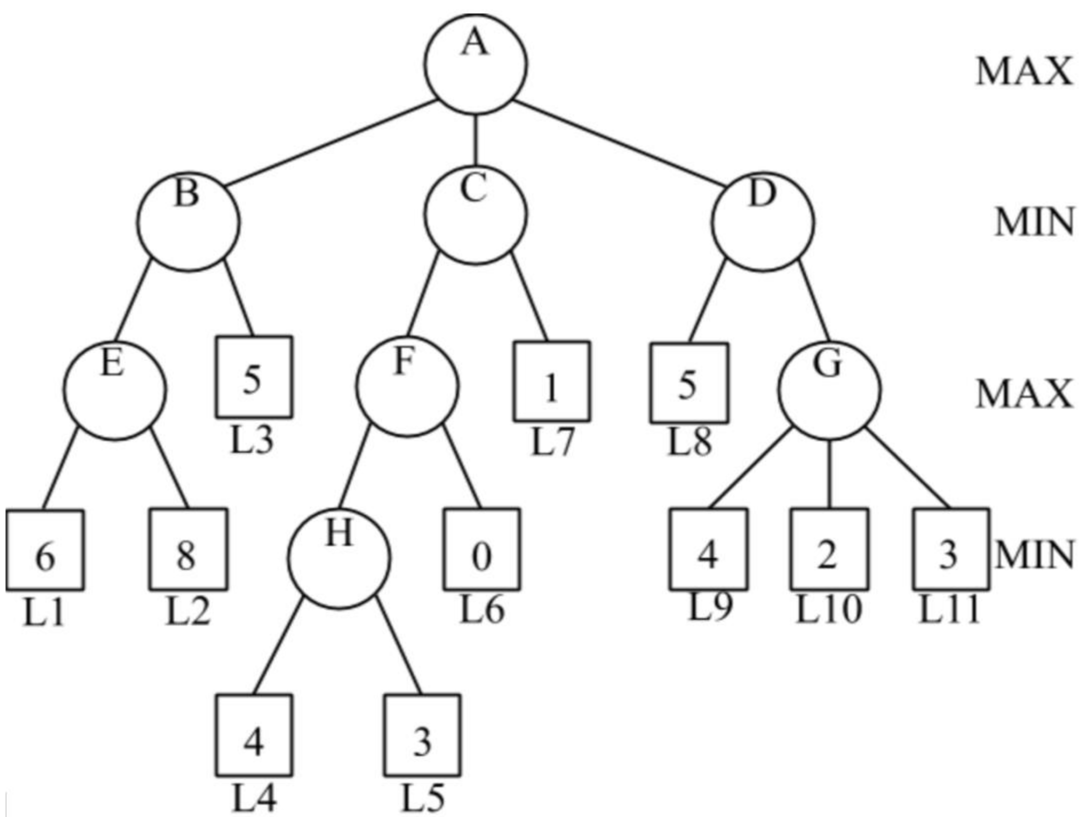
Part A: A Minimax Take-Over (12 points)

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 as a separate download.



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 (<u>without alpha-beta pruning</u>) 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

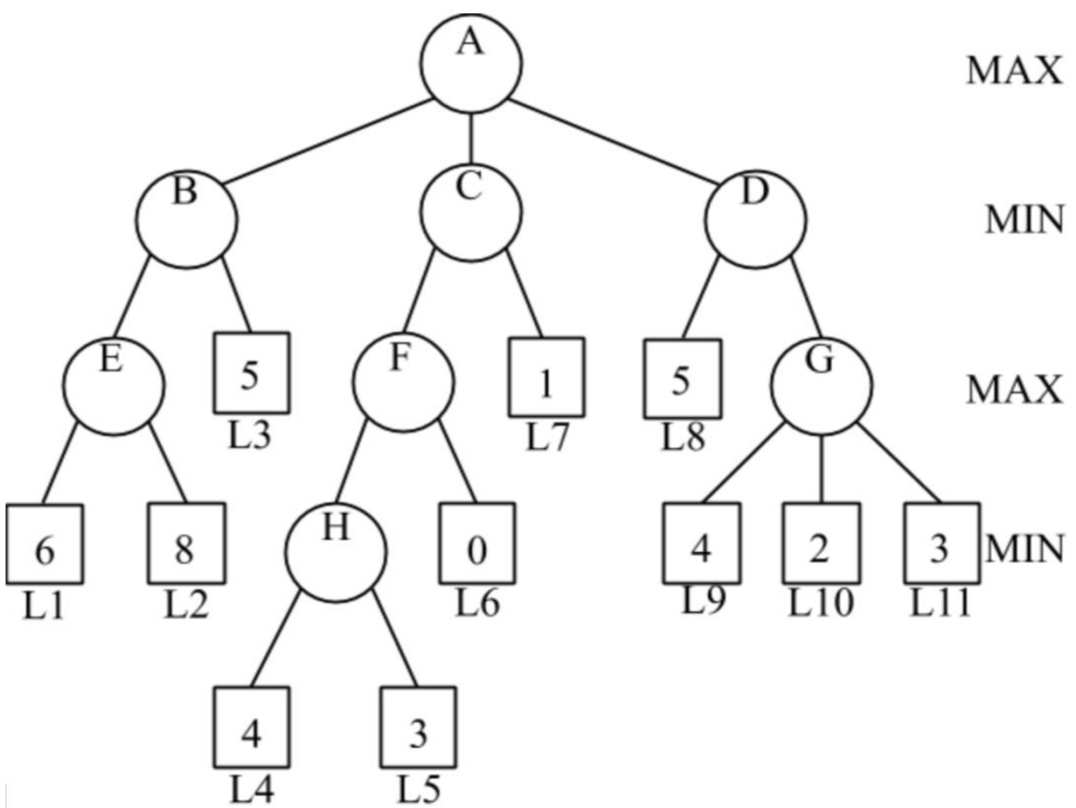
A4 (2 points) What is the Minimax path? Write the node labels in order.

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.



B2 (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

B3 (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

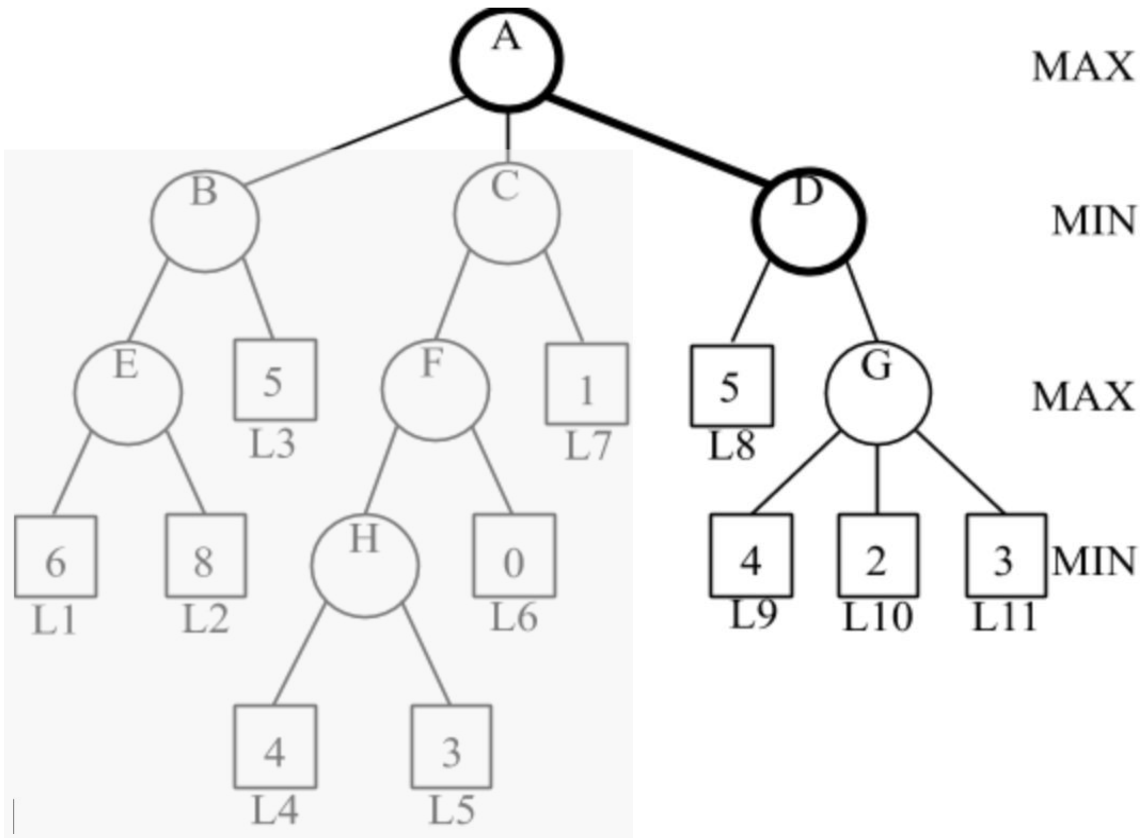
B4 (2 points) Could reordering the branches of the above tree increase the number of nodes that do not need to be evaluated during alpha-beta pruning? (Circle one.)

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

Problem 3: Constraint Satisfaction (34 points)

Part A: The Lost Schedule (18 points)

The New England Women's and Men's Athletic Conference (NEWMAC) has lost the schedule it created for NCAA football games! Luckily, the quarterback of the MIT Engineers is none other than Udgam Goyal, a TA for 6.034. "No problem," he says. "I can have my students draft up a new schedule in no time."

There are 6 teams that need to play a game next week. They are:
Babson, **C**lark, **E**merson, **M**IT, **S**mith, and **W**heaton

Schedule constraints:

- Each team must play in **only one** game, either Game 1, 2, or 3
- **Exactly two** teams must play in each Game.
- **B**abson must play in Game 1.
- Last week's matchups, shown in the schedule below, cannot be repeated: i.e., **B** vs **C**, **E** vs **M**, **S** vs **W** are not allowed in the new schedule.

Last week's schedule:

Game 1	**B**abson	**C**lark
Game 2	**E**merson	**M**IT
Game 3	**S**mith	**W**heaton

A1 (2 points) Fill in the table below with the initial domain values, i.e., game numbers, for each of the variables.

	Domain
B	
C	
E	
M	
S	
W	

A2 (14 points) Perform **Depth-First Search with Forward Checking and no propagation** (DFS+FC) to generate a schedule for the next week. **Draw your search tree in box below, using the order of variables provided.** *(If you want to start over, use the next page. If you write on both pages, clearly mark which page we are to grade.)*

B
C
E
M
S
W

A3 (1 point) Which team will play against **M (**MIT) next week?

B **C** **E** **S** **W**

A4 (1 point) Which teams were reassigned during backtracking? Circle **all that apply** or **None** if no backtracking occurred.

B **C** **E** **S** **W** **M** **None**

Part B: Rivalry Week and Domain Reduction (16 points)

Clark and **E**merson review your proposed schedule and insist that they need to play each other in the new schedule. Udgam Goyal also noticed that Game 1 is scheduled during 6.034 lecture, and Game 3 is during recitation. Therefore, **M**IT needs to play in Game 2. (These two additional new constraints are noted below.)

Schedule constraints:

- Each team must play in **only one** game, either Game 1, 2, or 3.
- **Exactly two** teams must play in each Game.
- Last week's matchups cannot be repeated, i.e., **B** vs **C**, **E** vs **M**, **S** vs **W** are not allowed.
- **B**abson must play in Game 1.

New

- **C**lark and **E**merson must play in the same Game.
- **M**IT must play in Game 2.

	Domain
B	1
C	1 2 3
E	1 2 3
M	2
S	1 2 3
W	1 2 3

B1 (15 points) Perform **Domain Reduction through singleton domains** (i.e., Prop-1 without search) to reduce the potential schedule choices as much as possible by filling out the table below. (There may be more rows than you need.) Initialize your propagation queue in alphabetical order.

Space is provided on the next page for you to show your work for partial credit.

Note: You don't need to do assignments; just reduce the domains.

	Variable de-queued	List all values just eliminated from neighboring variables or NONE
1	**B**	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

For partial credit, show your work here.

B2 (1 point) Which teams can **M (**MIT) play against in Game 2? Circle **all that apply**.

B **C** **E** **S** **W**