Midterm 1 Exam

CSCI 561 Spring 2024: Artificial Intelligence

Problems	**100 Percent total**
1- General AI Knowledge	10
2- Search	30
3- Game Playing	20
4- CSP	20
5- Propositional Logic	20

DO NOT OPEN EXAM UNTIL YOU ARE TOLD TO

Instructions:

1. Date: **Monday Feb 12, 3:00pm - 4:50pm**
2. Maximum credits/points/percentage for this midterm: 100
3. The percentages for each question are indicated in square brackets [ ] near the question.
4. **No books** (or any other material) are allowed.
5. **Write down your name, student ID and USC email address.**
6. **Your exam will be scanned and uploaded online.**
7. **Write within the boxes provided for your answers.**
8. **Do NOT write on the 2D barcode.**
9. **Do not write within less than 1” from the paper edges to avoid lost work during scanning.**
10. **The back of the pages will not be graded. You may use it for scratch paper.**
11. **The back of the pages will not be scanned. Do not write any answer there!**
12. No questions during the exam. **If something is unclear to you, write that in your exam.**
13. **Be brief: a few words are enough if using the correct vocabulary studied in class.**
14. When finished, raise completed exam sheets until approached by proctor.
15. **Adhere to the Academic Integrity code.**

1. [10%, 1% each, no partial] General AI Knowledge

For each of the statements below, fill in the bubble **T** if the statement is **always and unconditionally true**, or fill in the bubble **F** if it is **always false, sometimes false, or just does not make sense**.

1.	T	F
2.	T	F
3.	T	F
4.	T	F
5.	T	F
6.	T	F
7.	T	F
8.	T	F
9.	T	F
10.	T	F

1. A computer must be able to analyze visual information to pass all Completely Automated Public Turing test to tell Computers and Humans Apart (CAPTCHA). (T, lecture L01, pages P39-40)

2. Creating new Intelligent Agents involves the development of new hardware and programming languages. (F, L01, P53)

3. The design of an agent largely depends on the environment where the agent will be working, e.g., whether the environment is accessible or deterministic. (T, L02-03, P23)

4. Picking a random successor state from the current state is a core strategy in many of the searching algorithms, including both simulated annealing and A*. (F, as it is true for simulated annealing L04, P45, but not for A* L02-03, P86 shows the pseudo code for all tree search methods studied, and we expand all children)

5. The effectiveness and efficiency of alpha-beta pruning is not affected by the ordering of the moves. (F, L05~06, P36)

6. The alpha-beta pruning introduced in the lecture is an optimization strategy specifically for the Min-max algorithm but pruning to reduce a search space is a generic strategy that can be applied to various algorithms. (T, L07)

7. It is possible to solve a CSP with an informed search algorithm. (T, L07, P15 shows uninformed. Your reasoning and understanding of search algorithms should deduct that informed algos would work too)

8. In CSP, a single variable is node-consistent if all the values in its domain satisfy the variable's unary constraints and a variable is arc-consistent if every value in its domain satisfies its binary constraints. (T, L07, P30)

9. There are different types of logic such as propositional logic, first-order logic, temporal logic, etc. The ontological commitment of propositional logic includes facts, objects, and relations. (F, L08, P19)

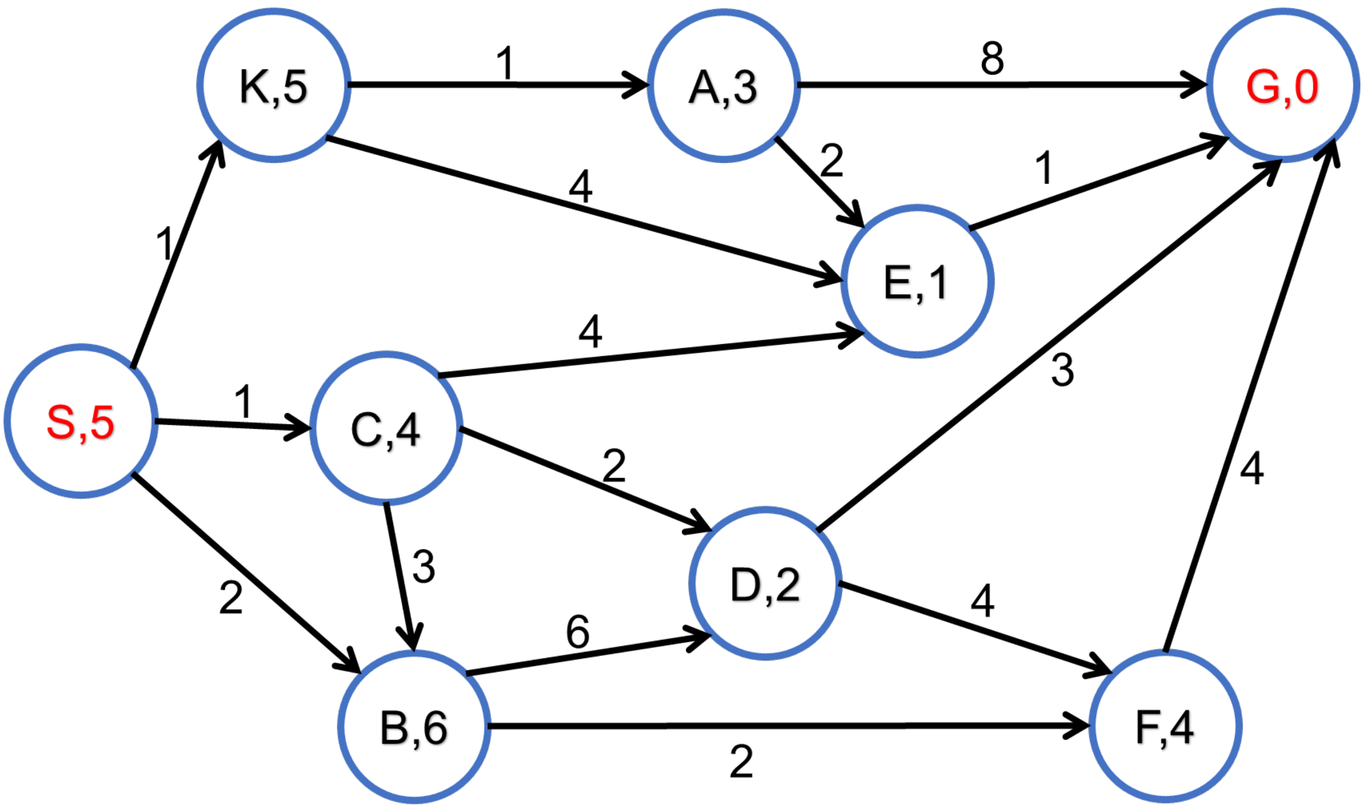
10. Truth tables can, in principle, be used to solve all problems in propositional logic by enumerating all possible truth values, but they have limitations in their complexity and efficiency. (T, L08, P29, P32, P34)

Each answer is worth 1%.

2. [30%] Search

Consider the following graph. The start node is S, and the goal node is G. The cost of each transition is shown on the corresponding edge, and the heuristic values are in the nodes.
NOTE:

- ***When all else is equal, expand the nodes in alphabetical order. E.g., in UCS, if you are expanding to two child nodes Y and Z from the same parent X, and the expected path costs g(n) are the same, you should expand to Y before Z.***
- ***Each answer below should be a sequence of states, like, e.g., "S N_1 N_2 N_3 G".***
- ***Note how the arcs are oriented (you can only go in the direction of the arrow).***
- ***Loop detection: apply the "clean and robust algorithm" studied in class.***



2A. [6%, -1% for each missing/extra node] BFS

[4%] Order of Expanding	[2%] Solution Path
SBCKDFEAG **NOTE: 'S' and 'G' are optional**	**SBDG**

2B. [6%, 2% each, -1% for each missing/extra node] DFS

[3%] Order of Expanding	[3%] Solution Path
SBDG **NOTE: ‘S’ and ‘G’ are optional**	**SBDG**

2C. [6%, 3% each, -1% for each missing/extra node] Uniform cost search (UCS)

[4%] Order of Expanding (Don’t list duplicate nodes unless the path value is updated)	[2%] Solution Path
SCKABDEFG **NOTE: ‘S’ and ‘G’ are optional**	**SKAEG**

2D. [6%, 3% each, -1% for each missing/extra node] A* Search

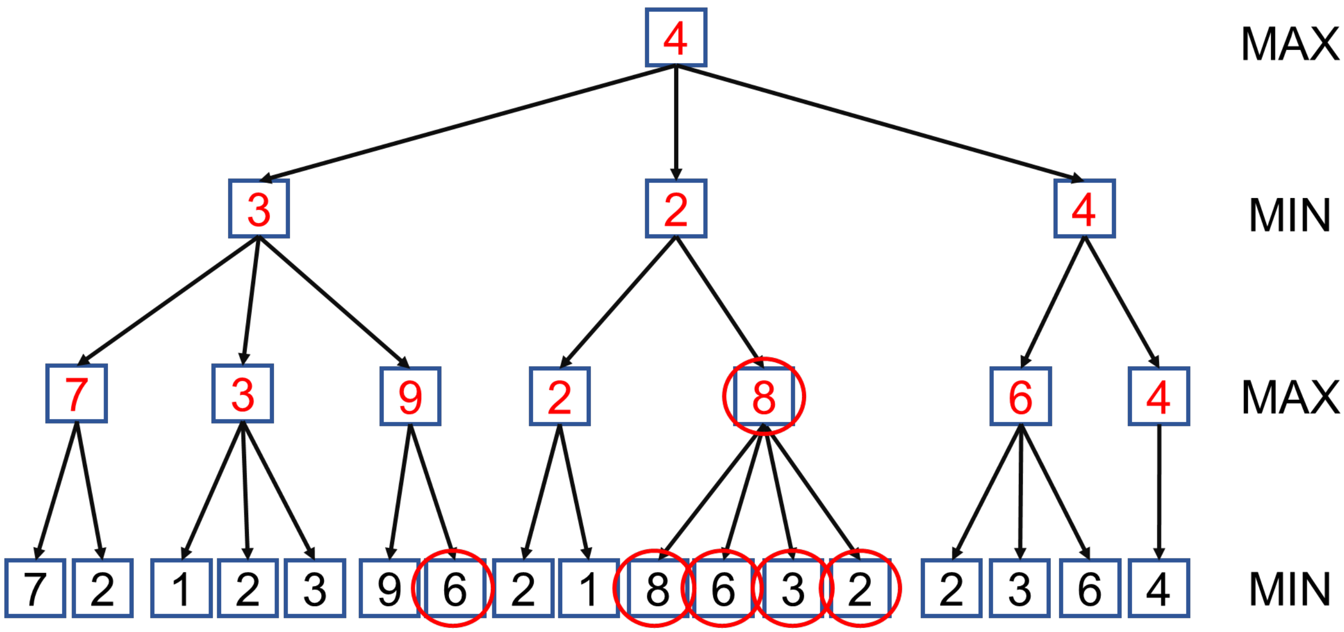
[4%] Order of Expanding (Don’t list duplicate nodes unless the path value is updated)	[2%] Solution Path
SCDEKAEG **NOTE: ‘S’ and ‘G’ are optional**	**SKAEG**

2E. [6%, 3% for answering “No”, 3% for nodes, no partial] Is the heuristics admissible? Please answer “Yes” or “No”. If yes, explain why. If no, list the node(s) that violate the rule.

No. K

3. [20%] Game Playing

Consider the following game tree in which the evaluation function values are shown inside each leaf node. Assume that the root node corresponds to the maximizing player. ***Assume that the search always visits children left-to-right.***



3A [6%**, -1% for each mistake, down to 0**] Compute the backed-up values using the minimax algorithm. **Write your answers inside each node (square box).**

3B [8%**, -2% for each mistake (node) , down to 0**] Which nodes will not be examined by the alpha-beta pruning algorithm? **Show your answer by circling all the nodes (or circling the entire subtree when appropriate) in the tree that will be pruned.**

3C [6%**, no partial**] If the MINs and MAXs in the given graph are reversed, which means the top node is MIN, how many nodes will not be examined by the alpha-beta pruning algorithm? **Answer with a number.**
2

You may use the area below for rough work. It will not be graded. The exam continues next page.

4. [20%] CSP

Consider the following minesweeper problem in a 7x6 grid consisting of 6 rows (1 to 6) and 7 columns (A to G).

- Every cell can be represented by a combination of a letter and a number, e.g., A1, E2, etc.
- Every **grey** cell contains nothing and should not be considered when you solve the problem.
- Every **blank** cell can either be **dangerous** (with a mine) or **safe** (no mine).
- There is at most one mine in each cell.
- Every grid cell with a **number** has some mine(s) around it, and the number indicates the number of adjacent mines (horizontally, vertically, and diagonally).

	A	B	C	D	E	F	G
1			1				
2			1	1	1	1	
3						1	
4			1	1	2	3	
5	1	1	3				
6							

To come up with a general solution to this kind of problem, you need to turn it into a CSP.
Here is where you start from to construct your solution:

- **Variables:** blank cells. E.g., D1, E1, …, A6.
- **Domain:** The domain of each variable is {dangerous, safe}.
- **Constraints:** Defined for cells with numbers. E.g., C5=3 means there are three mines in cells D5, B6, C6, D6.

Answer the following questions based on the given information.

4A [12%, **1% for each cell, -0.5% for each mistake within a cell, down to 0 for each cell**] Fill in the table to list all initial constraints (C5 has been given as an example). A constraint consists of a set of involved nodes and the number of mines in the cells considered.

C1	D1, 1
C2	D1, 1
D2	D1, E1, 1
E2	D1, E1, F1, 1
F2	E1, F1, G1, G2, G3, 1
F3	G2, G3, G4, 1
C4	D5, 1
D4	D5, E5, 1
E4	D5, E5, F5, 2
F4	E5, F5, G5, G4, G3, 3
A5	A6, B6, 1
B5	A6, B6, C6, 1
C5	D5, B6, C6, D6, 3 (example)

4B [8%**, 4% for each solution; giving additional solution will get -4% directly; in each solution, -1% for each error in any of the cells; each solution down to 0, no negative**] Give all possible solutions to this problem by drawing crosses (X) in the blanks for all mine locations.

First possible solution, or leave blank if there is no solution:

	A	B	C	D	E	F	G
1			1	X			X
2			1	1	1	1	
3						1	
4			1	1	2	3	X
5	1	1	3	X		X	X
6		X		X			

Second possible solution, or leave blank if there are fewer than two solutions:

	A	B	C	D	E	F	G
1			1	X			
2			1	1	1	1	
3						1	X
4			1	1	2	3	
5	1	1	3	X		X	X
6		X		X			

Third possible solution, or leave blank if there are fewer than three solutions:

	A	B	C	D	E	F	G
1			**1**				
2			**1**	**1**	**1**	**1**	
3						**1**	
4			**1**	**1**	**2**	**3**	
5	**1**	**1**	**3**				
6							

You may use the area below for rough work. It will not be graded. The exam continues next page.

5. [20%] Propositional Logic

5A [14%, 2% for each sentence, no partial, the credits should be granted as long as the meaning is the same] Translation. Translate the following natural language sentences to propositional logic statements with the logic symbols you learned from lectures (∧, →, ¬, (), etc.) and given symbols for sentences (P, Q, etc.)

Sentence 1 - "If it is raining, then the ground is wet." (let **P** represent "it is raining" and **Q** represent "the ground is wet").

$P \rightarrow Q$

Sentence 2 - "Either the train is late, or I will miss my meeting, but not both." (**R** for "the train is late" and **S** for "I will miss my meeting")

(R ^ ~S) v (~R ^ S)

Or, equivalently,

$(R \vee S) \wedge \neg(R \wedge S)$

Sentence 3 - "It is not true that 'if the computer is running, then the software is error-free'." (**T** for "the computer is running" and **U** for "the software is error-free")

$\neg(T \rightarrow U)$

Sentence 4 - "The garden is beautiful if and only if ‘the flowers are blooming, and the sun is shining’." (**V** for "the garden is beautiful", **W** for "the flowers are blooming", and **X** for "the sun is shining").

$V \leftrightarrow (W \wedge X)$

Sentence 5 - "If I study hard and sleep well, then I will pass the exam." (**Y** for "I study hard", **Z** for "I sleep well", and **A** for "I will pass the exam").

$(Y \wedge Z) \rightarrow A$

Sentence 6 - "If either the internet is down or the power is out, I cannot work, unless I have a charged laptop." (**B** for "the internet is down", **C** for "the power is out", **D** for "I cannot work", and **E** for "I have a charged laptop").

$(B \vee C) \wedge \neg E \rightarrow D$

Sentence 7 - "The car is functioning well, and the weather is **not** bad. I will go on a trip if I don't have urgent work." (F for "the car is functioning well", G for "the weather is bad", H for "I will go on a trip", and K for "I have urgent work").

$(F \wedge \neg G) \wedge (\neg K \rightarrow H)$

5B [4%, -0.5 for each error, down to 0] Fill the following partial truth table (with **T/F**) for the given sentence: $\mathbf{(P \wedge Q) \rightarrow (R \vee S)}$ for P = F(False). In question 5B we are only concerned with situations where P is false.

P	**Q**	**R**	**S**	**$(P \wedge Q) \rightarrow (R \vee S)$**
F	T	T	T	T
F	T	T	F	T
F	T	F	T	T
F	T	F	F	T
F	F	T	T	T
F	F	T	F	T
F	F	F	T	T
F	F	F	F	T

5C [2%, 1% for "No", 1% for correct values.] Is the sentence, $\mathbf{(P \wedge Q) \rightarrow (R \vee S)}$, always True? If yes, answer "Yes". If no, answer "No", and give one example of T/F values for P, Q, R, S when the sentence is False. Answer: ___________

No

P	**Q**	**R**	**S**	**$(P \wedge Q) \rightarrow (R \vee S)$**
T	T	F	F	F