CSCI 561 Fall 2019: Artificial Intelligence

Problems	100 Percent total
1- General AI Knowledge	10
2- Search	30
3- Game Playing	20
4- CSP I	20
5- CSP II	10
6- Multiple Choice related to Discussions	10

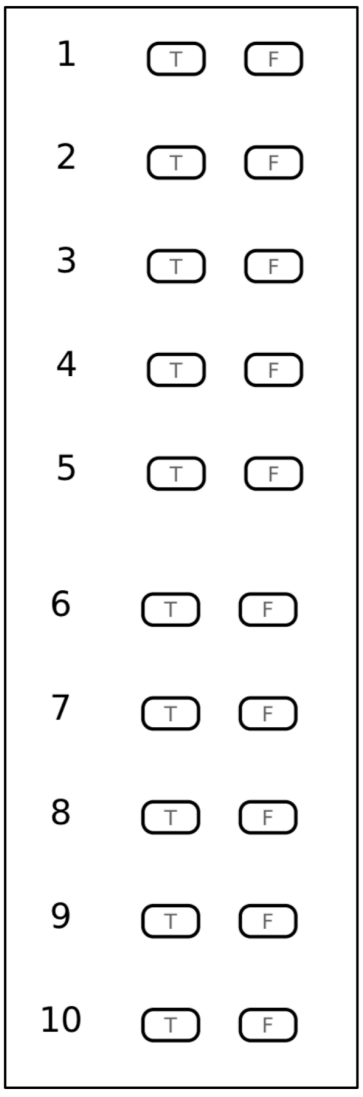
DO NOT OPEN EXAM UNTIL YOU ARE TOLD TO

Instructions:

1. Date: **10/4/2019 from 2:00 pm – 3:30 pm in SAL 101, THH 202, SGM 101, SGM 123**
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 precise and 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%] 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- A rational agent is guaranteed to be successful. F

2- The real world is not accessible. T

3- A* is optimal when the heuristic function h(n) is complete. F

4- Learning agents use a critic to evaluate performance and adapt. T

5- 23 n + 56 n^2 + 178,000 n log(n) is o(n^2) F it is O(n^2)

6- Tree search algorithms work by expanding a tree of states. F tree of nodes

7- Genetic algorithms use the makeover operator to create two children from two parents. F crossover

8- In Expecti-minimax for games with chance nodes, the exact evaluation function values do directly affect the outcome of the algorithm, as opposed to only their relative ordering. T

9- Min-conflicts is a local search algorithm for CSPs. T

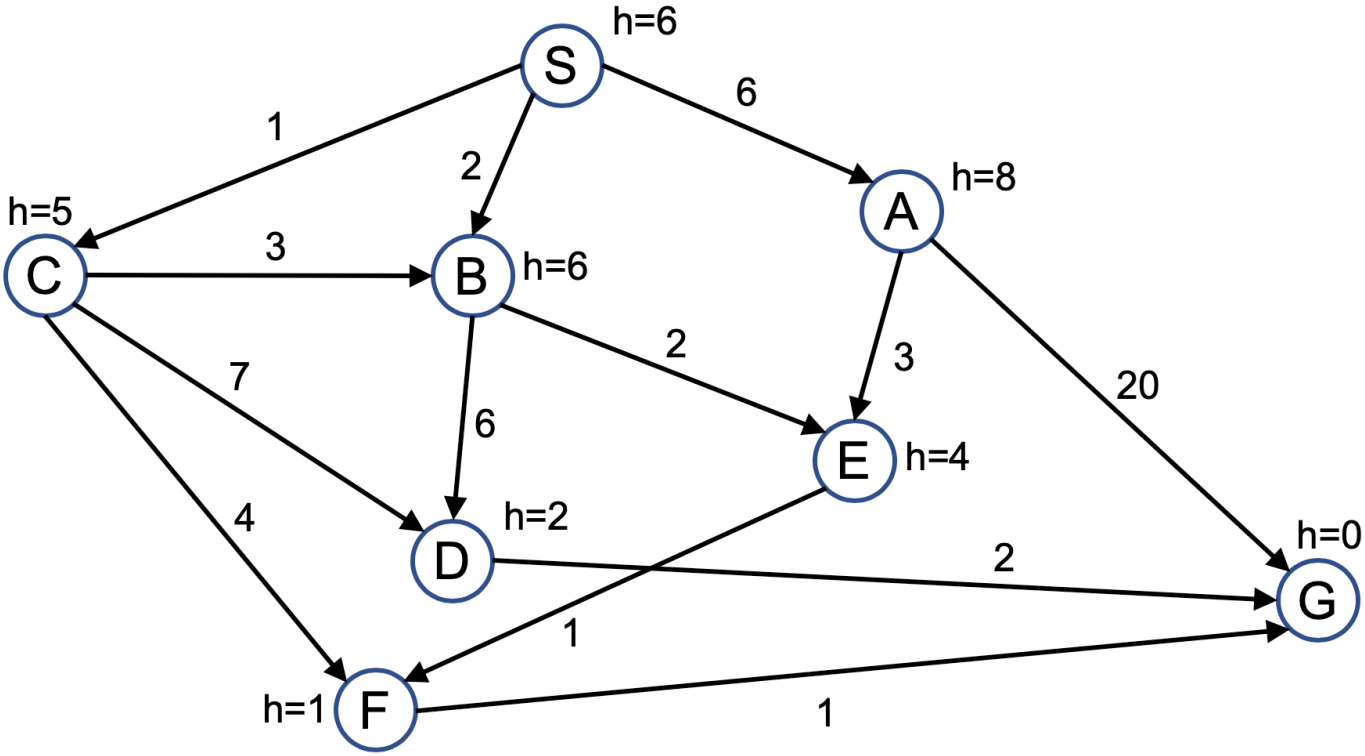
10- Simulated annealing is always guaranteed to find the optimal solution under any temperature schedule, thanks to the proof of Geman & Geman (1984). F not any schedule

Each answer is worth 1%.

2. [30%] Search

RUBRIC: -1% for any error

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 h value of each node is shown next to each node. ***When all else is equal, pop the nodes off the front of the queue in alphabetical order. Each answer below should be a sequence of states, like, e.g., "S-A-B-C-D-E-F-G". Note how the arcs are oriented. Loop detection: apply the "clean and robust algorithm" studied in class.***



2A. [4%] BFS

[2%] Order of nodes popped off open queue	[2%] Solution Path
S – A – B – C – E – G	S – A – G

2B. [4%] DFS

[2%] Order of nodes popped off open queue	[2%] Solution Path
S – A – E – F – G	S – A – E – F – G

2C. [6%] UCS

[4%] Order of nodes popped off open queue	[2%] Solution Path
S – C – B – E – F – A – G	S – C – F – G

2D. [6%] Greedy Best-first Search

[4%] Order of nodes popped off open queue	[2%] Solution Path
S – C – F – G	S – C – F – G

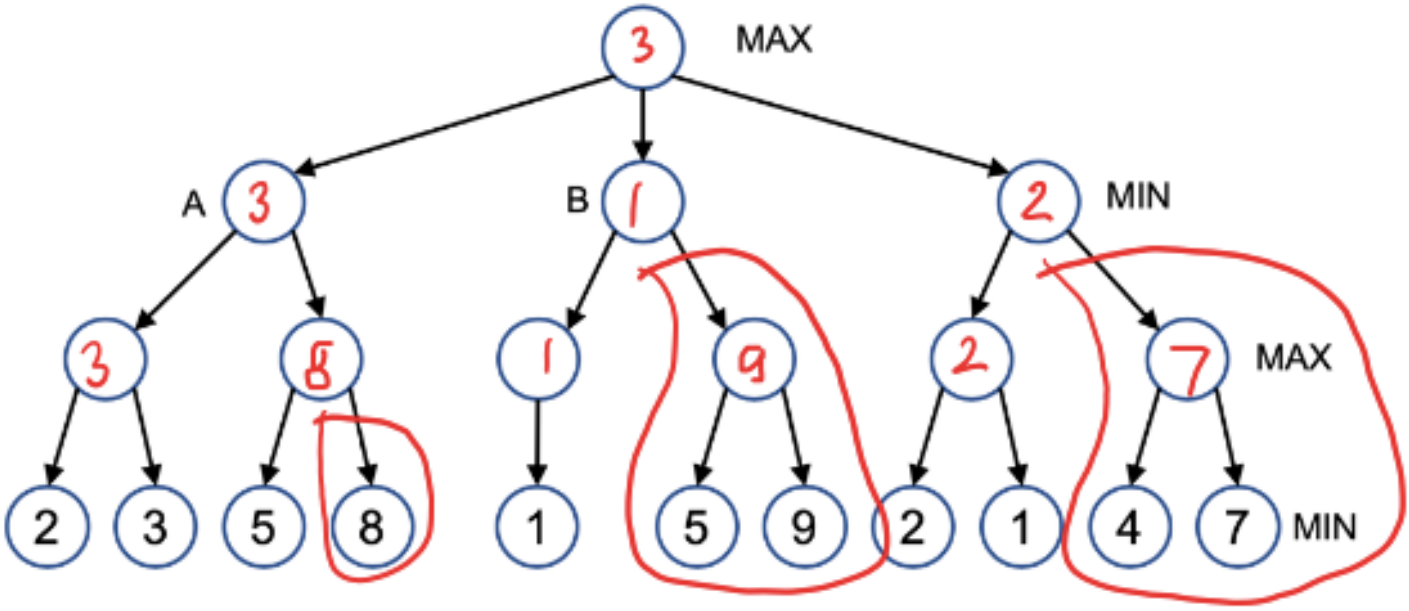
2E. [6%] A* Search

[4%] Order of nodes popped off open queue	[2%] Solution Path
S – C – F – G	S – C – F – G

2F. [4%] Is the heuristic admissible? Circle one: YES NO

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.***



(a) [4%] Compute the backed-up values using the minimax algorithm. **Show your answer by writing values inside the appropriate nodes in the above tree.**
RUBRIC: -1% for each incorrect node in minimax
For the alpha beta pruning (part c), +8, if the answer contains all the 3 correct pruned branches, +5 for 2 correct pruned branches, +3 for 1 correct pruned branch, and 0 for anything else. -1 if extra branch marked (4 branches marked instead of 3)

(b) [8%] In the figure above, assume that one and only one node can be a chance node. That is, the successor to that node is determined by a coin toss, not by the utility-maximizing choices of a player. In this version of the game, assume the minimum value of an outcome is zero.
RUBRIC: For all the questions below, +2 if the answer is correct, +1 if the answer is partially correct, 0 for anything else.

b.A.1 [2%] Describe how the minimax exploration would change if node A were the chance node.

See green highlighted text on page 6

b.A.2 [2%] Would the value at the root node change? Please explain your answer.

See green highlighted text on page 6

b.B.1 [2%] Describe how the minimax exploration would change if node B were the chance node.

See green highlighted text on page 6

b.B.2 [2%] Would the value at the root node change? Please explain your answer.

See green highlighted text on page 6

(c) [8%] Which nodes will not be examined by the alpha-beta pruning algorithm? **Show your answer by circling in the tree on previous page all the nodes that will be pruned.**

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

Either approach accepted as correct:

3bAi: A = (3*0.5 + 8*0.5) = 5.5
3bAii: yes, value at the root changes to 5.5

or

3bAi: B is 3 or at least 5
3bAii: maybe

then accept either one as correct:

3bBi: B=(1*0.5 + 9*0.5) = 5
3bBii: yes, value at the root changes to 5

or

3bBi: B is 1 or (at least 5, or 9)
3bBii: maybe

4. [20%] CSP I

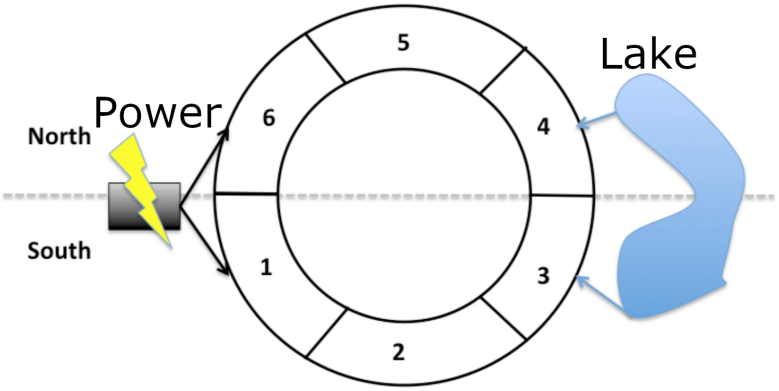
Apple's new circular-shaped campus
that opened in 2017 has been a
delight for its employees, but higher
management decided that it is time
to seriously optimize the location of the various offices in the circular building.

The campus has six office locations, labeled 1 through 6, and six departments:

- Legal (L)
- Maps Team (M)
- Prototyping (P)
- Engineering (E)
- Tim Cook's office (T)
- Secret Storage (S)

Offices can be **next to** one another, if they share a wall (for an instance, Offices 1 and 6). Offices can also be **across** from one another (specifically, Offices 1 and 4, 2 and 5, 3 and 6).

The **Electrical Grid** is connected to offices 1 and 6. The **Lake** is visible from offices 3 and 4. There are two "halves" of the campus – **South** (Offices 1 to 3) and **North** (Offices 4 to 6).



The constraints are as follows:

i. (L)egal wants a view of the lake to look for prior art examples.
ii. (T)im Cook's office must not be across from (M)aps.
iii. (P)rototyping must have an electrical connection.
iv. (S)ecret Storage must be next to (E)ngineering.
v. (E)ngineering must be across from (T)im Cook's office.
vi. (P)rototyping and (L)egal cannot be next to one another.
vii. (P)rototyping and (E)ngineering must be on opposite sides of the campus (if one is on the North side, the other must be on the South side).
viii. No two departments may occupy the same office.

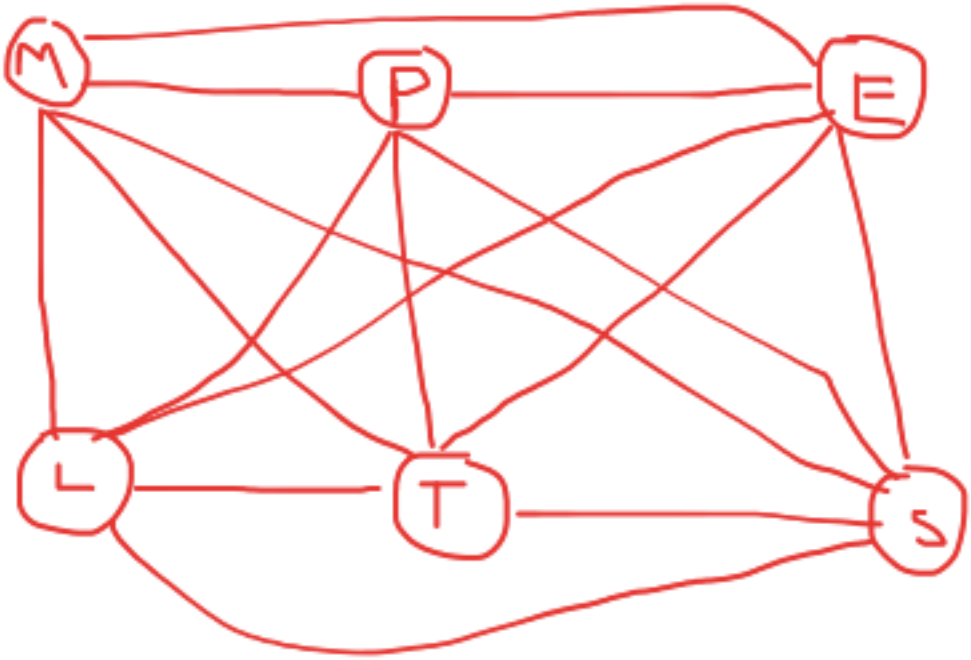
(a) [8%] Constraints.

Note: There are multiple ways to model
constraint viii. In your answers below,
assume that constraint viii is modeled
as multiple pairwise constraints, not a large n-ary constraint.

(a.i) [1% no partial credit] Circle your answers below to indicate which constraints are unary:

i ii iii iv v vi vii viii

(a.ii) [6%] Draw the constraint graph for this CSP
Rubric: -1% for each incorrect line until 0%



(a.iii) [1%] Write out an explicit form of constraint iii using variables and domains of the problem.
RUBRIC: no partial credit
P = {1,6}

(b) [12%] Domain Filtering.
We strongly recommend that you
use a pencil for the following problems.

RUBRIC for both bi and bii: +6 if all the answers are correct, +3 if 2 of them are wrong, +2% if 3 errors (3 correct), +1% if 4 errors (2 correct), and 0 if anything else is marked

(b.i) [6%] The table below shows the variable domains after unary constraints have been enforced and the value 1 has been assigned to variable P.

Cross out all values that are eliminated by running **Forward Checking** after this assignment.

L			3	4		
M	1	2	3	4	5	6
P	1					
E	1	2	3	4	5	6
T	1	2	3	4	5	6
S	1	2	3	4	5	6

(b.ii) [6%] The table below shows the variable domains after unary constraints have been enforced, the value 1 has been assigned to the variable P, and then the value 3 has been assigned to variable T.
Cross out all values that are eliminated if **arc consistency** is enforced after this assignment. (Note that enforcing arc consistency may include and absorb previous pruning).

L			3	4		
M	1	2	3	4	5	6
P	1					
E	1	2	3	4	5	6
T			3			
S	1	2	3	4	5	6

5. [10%] CSP II

This constraint satisfaction problem is a simplified version of Sudoku in a 4x4 matrix. The goal is to fill in each cell in the matrix with a number between 1 and 4 in such a way that no number is repeated on the same column or on the same row. To save you time, some cells have already been filled in with a value. The remaining ones have been named with a letter for easy reference. These letters, A, B, C, D, E, F and G, are the variables in the constraint satisfaction problem.

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

Variables: A, B, C D, E, F, and G.

Domain: The domain of each variable is {1, 2, 3, 4}.

Constraints: There is a constraint between each pair of cells P and Q that belong to the same column or to the same row of the matrix stating that the values assigned to the two cells cannot be equal.

Answer the questions below as if you were an agent following the CSP algorithms we studied in class.

A [5%] Fill in the table below (some values are provided as examples to guide you. For instance, A has two remaining values, 1 and 4, and it has constraints with four other variables B, C, D, G.):

Variable	A	B	C	D	E	F	G
Remaining values	1, 4	4	3	2, 3, 4	2	3,4	2
# of constraints with other variables	four	Two (A,F)	Three (A,D,G)	five	Two (D,F)	Three (B,D,E)	three (A,C,D)

Rubric: -1% per column, mistake in either box in the column makes it 0%. Student does NOT have to list which variables are constraints in the second row, it is acceptable to only give the number of constraints.

B [2%] Using the **Minimum Remaining Values (MRV)** heuristic, list the variable that the CSP search algorithm will select next.

If there are ties, list all the variables that have the same MRV.

Minimum number of remaining values for the variables is 1. Variables B, C, E and G all have remaining values equal to this MRV.

RUBRIC: +2 if the answer is correct, +1 if the answer is partially correct, 0 for anything else.

C [3%] If the above was a tie, use the **degree heuristic** (or **most constraining variable heuristic**, i.e., variable with the most constraints on remaining variables) to break the tie. What variable(s) would be selected? If a tie still remains, provide a systematic way to deal with the tie so that only one variable is selected. Explain your work.

We need to select a variable from (B, C, E, G) as we found in question #2. B and E have 2 constraining variables whereas C and G have 3 constraining variables. We should then choose either C or G. We can break this time arbitrarily using say alphabetical order. In this case, C is chosen.

RUBRIC: +3 if the answer is correct, +1 if the answer is partially correct, 0 for anything else.
Other acceptable systematic ways: random, select variable with the smallest row number, if row number same check for smallest column number, manhattan distance

6. [10%] Multiple Choice related to Discussions

Each question has zero or more correct choices.

Circle the letters (a., b., c., etc) of all correct choices.
Partial credit: beware that you lose 1% for each wrong answer, up to losing 2% for each question (so: all correct = 2%; 1 mistake = 1%, 2+ mistakes = 0%).

1. [2%] In the discussion, we showed several DARPA grand challenges for AI and Robotics, please circle all that are true. These DARPA grand challenges involve systems that can:

a. Self-drive from Los Angeles to Las Vegas.

b. Play Chess games with human grand master.

c. Perform fire-fighting tasks, including drive-to-site, enter-building, turn-on-water, drill-holes, climb stairs, etc.

d. Play Go games against human masters.

e. Pass the full Turing Test.

2. [2%] In the discussion, we discussed the characteristics of Deep Blue. Please circle all that are **true**:

a. Deep Blue's chess evaluation functions were learned by Deep Blue itself.

b. Deep Blue can sometimes search deeper than a human master.

c. Deep Blue's chess knowledge was solely developed by AI researchers.

d. Deep Blue used the A* search algorithm but nothing else.

e. Deep Blue used cloud computing.

3. [2%] In the discussion, we discussed the characteristic of A*'s heuristic function h(n). Please circle all that are **true**:

a. h(n) is the estimated future cost from n to goal.

b. If h(n)=0 for all n, then h(n) is admissible.

c. If h(n) is not admissible, then it will crash the A* algorithm.

d. If h(n) is admissible, then A* can always find the optimal solution without the g(n) function.

e. A* is a variation of the best-first search algorithm.

4. [2%] In the discussion, we discussed the characteristics of alpha and beta values for min-max search. Circle all that are **true**:

a. The meaning of the alpha value is “the least value that Max can already get”.

b. The meaning of the beta value is “the maximum value that Min would give so far”.

c. You can prune a search branch if the returned value from that branch is between alpha and beta.

d. Using the alpha and beta values will change the outcome of the basic min-max game playing.

e. The max-min algorithm would not work without the alpha and beta values.

5. [2%] In the discussion, we showed a variety of optimization techniques. Please circle all that are **true**:

a. Simulated Annealing is a non-deterministic algorithm.

b. Simulated Annealing guarantees finding the global extreme value in finite time.

c. There is a proof for why Genetic Algorithms can find the global extreme value in the evolution.

d. The optimization problem is one of the most fundamental problems in AI.

e. Constraint satisfaction problems cannot be solved by any optimization technique.