CS-171, Intro to A.I. — Final Exam — Fall Quarter, 2018

NAME:____ UCI NetID: _____________________

YOUR ID#: _________ ID# TO RIGHT: _________ ID# TO LEFT: ___________ ROW:_____ SEAT:_____

Please turn off all cell phones now.

The exam will begin on the next page. Please, do not turn the page until told.

When told to begin, check first to ensure that your copy has all the pages, as numbered 1-14 in the bottom-right corner of each page. We will supply a new exam for any copy problems.

The exam is closed-notes, closed-book. No calculators, cell phones, electronics.

Clear your desk except for pen, pencil, eraser, & water bottle. Put backpacks under your seat. Please do not detach the provided scratch paper from the exam.

After you first stand up from your seat, your exam is over and must be turned in immediately. You may turn in your Midterm exam early and leave class when you are finished.

This page summarizes the points for each question, so you can plan your time.

1. (12 pts total, 3 pts each) FOPL Unification/Resolution.
2. (10 pts total, -2 for each error, but not negative) Game Search.
3. (12 pts total, 3 pts each) Probability formulas.
4. (10 pts total, 2 pts each) English to FOL Conversion.
5. (12 pts total, 1 pt each) State Space Search.
6. (10 pts total, -1 for each mistake, but not negative) Bayesian Networks.
~~**7. (12 pts total, -2 for each mistake, but not negative) Local Search.**~~
8. (12 pts total, 1 pt each) SEARCH QUESTIONS.
9. (10 pts total, 1/2 pt each) SEARCH PROPERTIES.

The Exam is printed on both sides to save trees! Work both sides of each page!

1. (12 pts total, 3 pts each) FOPL Unification/Resolution. Use your knowledge of resolution and unification to unify and resolve the given FOPL clauses. For each pair of FOPL clauses below:

(1) Write the most general unifier (or MGU) that will allow you to perform resolution on those clauses, or write "None" if none is possible. Write your answer in the form of a substitution as given in your book, e.g. the substitution {x/John} means substitute x by John.

(2) Perform resolution on the two clauses and write the resulting clause, or write "True" if the resulting clause simplifies to True.

The first one is done for you as an example.

1.example.

¬ Rich(x) ∨ Unhappy(x)

Rich(John) **with θ =** {x/John}

____

Unhappy(John)

1.a. (3 pts total)

Knows(John, x)

¬ Knows(y, Elizabeth) ∨ Likes(y, x) **with θ =**

____

1.b. (3 pts total)

¬Water(x) ∨ ¬Food(x) ∨ InDesert(x, Cameraman(x))

Food(BearGrylls) **with θ =**

____

1.c. (3 pts total)

Actor(x) ∨ ¬Tall(x)

¬Actor(TonyStark) ∨ Tall(TonyStark) ∨ Movie(IronMan) **with θ =**

____

1.d. (3 pts total)

Neighbor(Penny, Friend(x)) ∨ Knows(x, y)

¬ Neighbor(y, Friend(Brother(Sheldon))) **with θ =**

____

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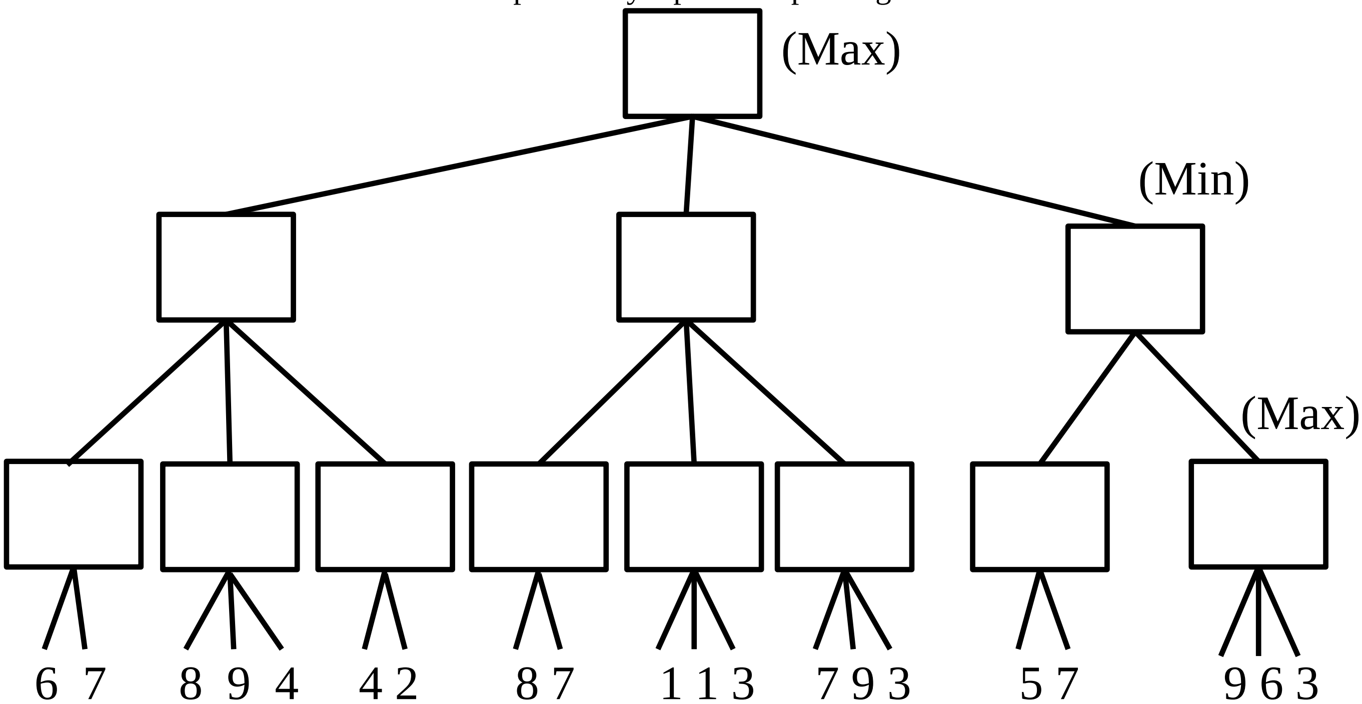
2. (10 pts total, -2 for each error, but not negative) Game Search. In the game tree below, it is Max's turn to move. Inside each leaf node is the estimated score of that resulting position as returned by the heuristic.

2.a. Perform Mini-Max search. Fill in each box with the value obtained from the mini-max search.
2.b. Cross out each node that would be pruned by alpha-beta pruning.



3. (12 pts total, 3 pts each) Probability formulas. For each term on the left, write the letter of the best description on the right. **The first one is done for you as an example.**

A	Probability Theory	A	Assigns each sentence a degree of belief ranging from 0 to 1
	Conditional independence	B	$P(a \wedge b) = P(a)\, P(b)$
	Independence	C	$P(a \wedge b \mid c) = P(a \mid c)\, P(b \mid c)$
	Product rule (chain rule)	D	$P(a \mid b) = P(b \mid a)\, P(a) / P(b)$
	Bayes' rule	E	$P(a \wedge b \wedge c) = P(a \mid b \wedge c)\, P(b \mid c)\, P(c)$

4. (10 pts total, 2 pts each) English to FOL Conversion. For each English sentence below, write the FOL sentence that best expresses its intended meaning.

Use **Student(x)** to mean that x is a student.
Use **Semester(y)** to mean that y is a semester/year.
Use **Took(s, c, y)** to mean that student s took course c in semester/year y.
Use **Passed(s, c, y)** to mean that student s passed course c in semester/year y.

The first one is done for you as an example.

4.example. Some student took French in Fall2018.

$\exists x \ Student(x) \land Took(x, French, Fall2018)$

4.a. Some student took French in Fall2018 and did not pass.

4.b. Every student in every semester who took French passed it.

4.c. There is some semester in which every student who took French passed it.

4.d. There is some semester in which some student took French and did not pass it.

4.e. Every semester there is some student who took French and passed it.

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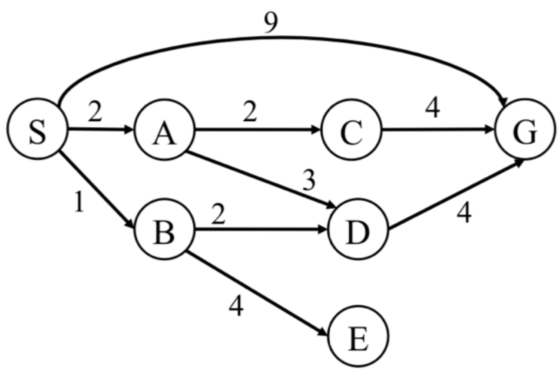
5. (12 pts total, 1 pt each) State Space Search. Execute Tree Search through this graph (do not remember visited nodes, so repeated nodes are possible). Step costs are given next to each arc, and heuristic values are given in the Heuristic table below. The successors of each node are indicated by the arrows out of that node. Successors are returned in top-to-bottom order (successors of S are G, A, B; successors of A are C and D; and successors of B are D and E; in that order). The start node is S and the goal node is G.

For each search strategy below, indicate (1) the order in which nodes are expanded; (2) the path to the goal that was found, if any; and (3) the cost of the path. Write "None" for path/cost if the goal was not found.

The first one is done for you as an example.



Heuristic

S	A	B	C	D	E	G
6	0	6	4	1	10	0

5.example. DEPTH-FIRST SEARCH:

5. example.(1) Order of expansion: _S G____

5. example.(2) Path to goal found: _S G_______________________ Cost of path to goal: __9____

5.a. (3 pts total, 1 pt each) BREADTH-FIRST SEARCH:

5.a.(1) Order of expansion: ____

5.a.(2) Path to goal found: _________________________ Cost of path to goal: ______

5.b. (3 pts total, 1 pt each) UNIFORM COST SEARCH:

5.b.(1) Order of expansion: ____

5.b.(2) Path to goal found: _________________________ Cost of path to goal: ______

5.c. (3 pts total, 1 pt each) GREEDY BEST FIRST SEARCH:

5.c.(1) Order of expansion: ____

5.c.(2) Path to goal found: _________________________ Cost of path to goal: ______

5.d. (3 pts total, 1 pt each) A* SEARCH:

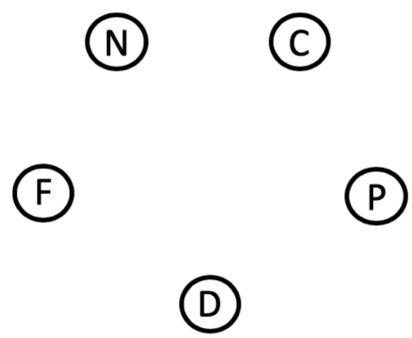
5.d.(1) Order of expansion: ____

5.d.(2) Path to goal found: _________________________ Cost of path to goal: ______

6. (10 pts total, -1 for each mistake, but not negative) Bayesian Networks. This question asks about a medical patient and conditions of nausea (N), cough (C), fever (F), pneumonia (P), and visiting a doctor (D).

- Nausea (N) and Cough (C) influence whether or not the patient may have a Fever (F).
- Cough (C) and Fever (F) influence whether or not the patient may have Pneumonia (P).
- Nausea (N), Cough (C), and Fever (F) influence whether the patient goes to see the doctor (D).
- In this question, assume that the probability of Nausea (N) and Cough (C) are independent.

6.1. (5 pts total, -1 for each mistake, but not negative) Draw the Bayesian Network corresponding to the probabilistic assumptions above.

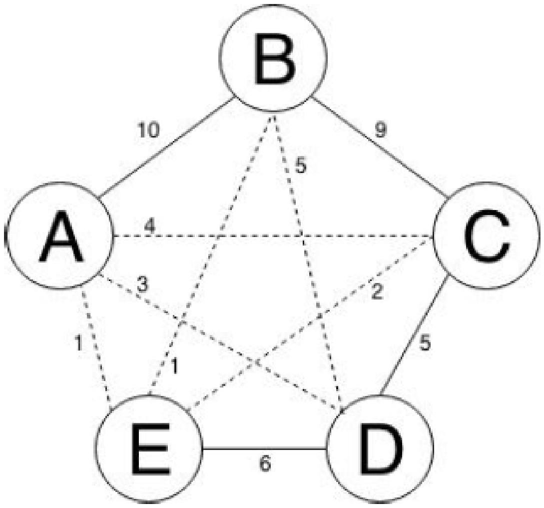


6.2. (5 pts total, -1 for each mistake, but not negative) Write down the corresponding factored form of the joint probability distribution. (Your answer here will be considered correct if it is correct relative to your Bayesian Network in problem 6.1 above, even if your answer to 6.1 was wrong.)

P(N, C, F, P, D) = ____

7. (12 pts total, -2 for each mistake, but not negative) Local Search. Consider this graph. The Traveling Salesman Problem (TSP) is to construct a path through the graph where (1) each node must be visited once, and (2) no node can be visited twice. Additionally, you seek the lowest-cost path satisfying those constraints.

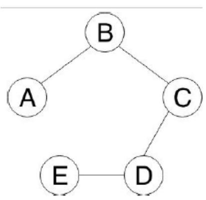
Question #7 was canceled. Everyone gets it question right, regardless of what they answered. After review of student feedback and discussion among the CS 171 Teaching Staff, we agreed that the question was poorly worded and did not capture properly our intended meaning.



You are a robot assigned to find a low-cost Traveling Salesman path through the graph above. You choose to use a local search. You will be given an initial state (a path) that satisfies the Traveling Salesman constraints, but is high-cost. A neighbor (successor) state is constructed by selecting an edge, deleting it, and replacing it with a new edge that maintains the Traveling Salesman constraints on the new state. Your goal is to move from neighbor to neighbor, always maintaining the Traveling Salesman constraint, seeking lower-cost paths.

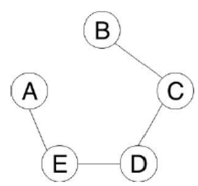
For a variable selection heuristic, select the edge with the current highest weight. Replace it with the edge of lowest weight that satisfies the constraints of the system. Write the total cost of the state next to each state. Continue until the algorithm has completed.

Initial State:



Cost = 30

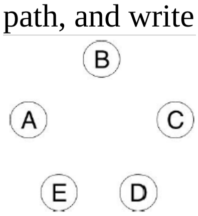
The first one is done for you as an example:



Cost = 21

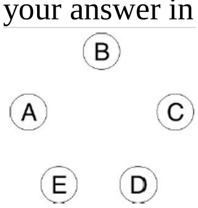
Continue the local search. At each step, select highest-cost edge and replace it with the edge of lowest weight that satisfies the Traveling Salesman constraints. Write the total cost of each state next to that state.

7.a. (6 pts total, -2 for each mistake, but not negative) Draw the next lowest-cost neighbor of the above-right path, and write its cost in the blank provided.



Cost = ____________

7.b. (6 pts total, -2 for each mistake, but not negative) Draw the next lowest-cost neighbor of the above path in 7.a, and write its cost in the blank provided. (Your answer will be considered correct if it is correct relative to your answer in 7.a above, even if your answer to 7.a was wrong.)



Cost = ____________

8. (12 pts total, 1 pt each) SEARCH QUESTIONS. Label the following as T (= True) or F (= False).

8.a. (1 pt) __________ An admissible heuristic NEVER OVER-ESTIMATES the remaining cost (or distance) to the goal.

8.b. (1 pt) __________ Greedy search is both complete and optimal when the heuristic is optimal.

8.c. (1 pt) __________ A consistent heuristic NEVER VIOLATES the triangle inequality.

8.d. (1 pt) __________ If the search space contains only a single local maximum (i.e., the global maximum is the only local maximum), then hill-climbing is guaranteed to climb that single hill and will find that global maximum.

8.e. (1 pt) __________ A* search is both complete and optimal for both tree and graph search whenever the step cost is bounded away from zero by a small positive number and the heuristic function is consistent.

8.f. (1 pt) __________ Hill-climbing has very attractive space properties because it uses only $O(bd)$ space.

8.g. (1 pt) __________ Simulated annealing will accept more and worse bad moves at a low temperature than at a high temperature.

8.h. (1 pt) __________ Simulated annealing uses *O*(*constant*) space and sometimes can escape from local optima.

8.i. (1 pt) __________ The simulated annealing temperature increases as the search progresses.

8.j. (1 pt) __________ If the search space is small enough for Mini-Max search to go all the way down to the leaves (e.g., in tic-tac-toe), then it will play a perfect (= optimal) game.

8.k. (1 pt) __________ Uniform-cost search is both complete and optimal when the minimum step cost is bounded away from zero by a small positive constant.

8.l. (1 pt) __________ Mini-Max search assumes that the opponent plays optimally, so the opponent can defeat it by playing sub-optimally.

9. (10 pts total, 1/2 pt each) SEARCH PROPERTIES. Fill in the values of the four evaluation criteria for each search strategy. Assume a tree search where b is the finite branching factor; d is the depth to the shallowest goal node; m is the maximum depth of the search tree; C* is the cost of the optimal solution; step costs are identical and equal to some positive ε; and in Bidirectional search both directions use breadth-first search. Note that these conditions satisfy all of the footnotes of Fig. 3.21 in your book.

Criterion	Complete?	Time complexity	Space complexity	Optimal?
Breadth-First				
Uniform-Cost				
Depth-First				
Iterative Deepening				
Bidirectional (if applicable)				

****** THIS IS THE END OF THE FINAL EXAM ******

Scratch Paper (1) Please Do Not Detach From Test

Scratch Paper (2) Please Do Not Detach From Test

Scratch Paper (3) Please Do Not Detach From Test

Scratch Paper (4) Please Do Not Detach From Test