

CS-171, Intro to A.I. — Midterm Exam — Summer Session 1, 2018

YOUR NAME: _____

YOUR ID: _____ ID TO RIGHT: _____ 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 1-12 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. (15 pts total) PROPOSITIONAL LOGIC.
2. (15 pts total, 3 pts each) SEARCH STRATEGIES.
3. (5 pts total, -1 pt for each error, but not negative) MINI-MAX SEARCH IN GAME TREES.
4. (10 pts total, -1 for each error, but not negative) ALPHA-BETA PRUNING.
5. (6 pts total, 1 pt each) Logic Concepts.
6. (12 pts total, 1 pt each) Properties of task environments.
7. (15 pts total, 5 pts each, -1 for each error, but not negative) BAYESIAN NETWORKS.
8. (7 pts total, 1 pt each) The Knowledge Engineering process.
9. (6 pts total, 1 pt each) Logic-To-English.
10. (9 pts total, 1 pt each) Probability concepts and formulae.

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

1. (15 pts total) PROPOSITIONAL LOGIC. You are a logical agent who has been given the following sentence as your knowledge base (KB): $(A \rightarrow C) \wedge (C \rightarrow A) \wedge (B \rightarrow C)$

1.a. (2 pts) Convert the sentence above into CNF (Conjunctive Normal Form)

1.b. (5 pts, -1 each error, but not negative) Fill in the following truth table for your knowledge base. The first one is done for you as an example.

A	B	C	KB
T	T	T	T
T	T	F	
T	F	T	
T	F	F	
F	T	T	
F	T	F	
F	F	T	
F	F	F	

1.c. (2 pts, -1 each error, but not negative) List all the possible worlds that are models of KB. List each possible world as $(A=T/F, B=T/F, C=T/F)$, where T/F are chosen to correspond to one row in the table above. The first one is done for you as an example.

$(A=T, B=T, C=T),$

1.d. (2 pts) Does your knowledge base entail $\neg (A \wedge B)$? (Answer Yes or No.)

1.e. (2 pts, -1 each error, but not negative) You learned a new sentence, $\neg C$, and added it to your existing KB to make a new KB. List all the possible worlds that are models of your new KB.

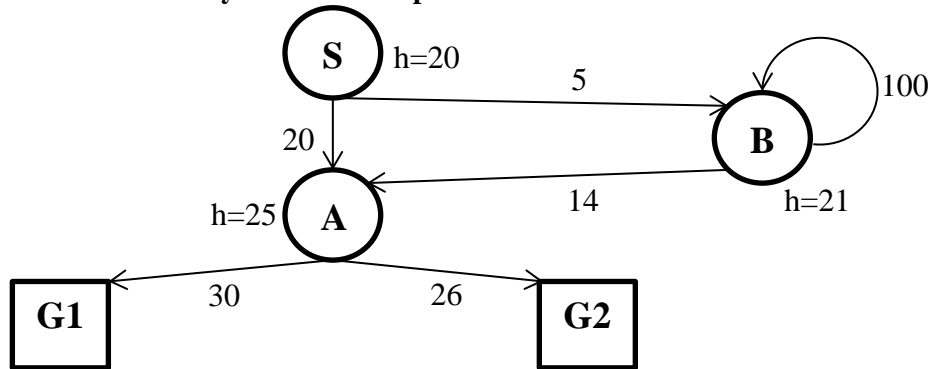
1.f. (2 pts) Does your new knowledge base entail $\neg (A \wedge B)$? (Answer Yes or No.)

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2. (15 pts total, 3 pts each) SEARCH STRATEGIES. Execute Tree Search through this graph (i.e., do not remember visited nodes, so repeated nodes are possible). It is not a tree, but pretend that you don't know that it is not. S is the start node and G1, G2 are the two goal nodes.

Step costs are given next to each arc. Heuristic values are given next to each node (as $h=x$). The successors of each node are indicated by the arrows out of that node. **Successors are returned in left-to-right order. Successors of S are A, B; successors of A are G1, G2; successors of B are A, B; in those orders.**

For each search strategy below, show the order in which nodes are expanded (i.e., to expand a node means that its children are generated). If stuck in a loop, indicate the looping sequence of states. Show the path from start to goal, or write "None". **The first one is done for you as an example.**



2.a. (example) DEPTH FIRST SEARCH.

Order of node expansion: S A G1

Path found: S A G1

2.b. (3 pts total) BREADTH FIRST SEARCH.

(2 pt) Order of node expansion: _____

(1 pt) Path found: _____

2.c. (3 pts total) UNIFORM COST SEARCH.

(2 pts) Order of node expansion: _____

(1 pt) Path found: _____

2.d. (3 pts total) GREEDY (BEST-FIRST) SEARCH.

(2 pts) Order of node expansion: _____

(1 pt) Path found: _____

2.e. (3 pts total) ITERATED DEEPENING SEARCH.

(2 pts) Order of node expansion: _____

(1 pt) Path found: _____

2.f. (3 pts total) A* SEARCH.

(2 pts) Order of node expansion: _____

(1 pt) Path found: _____

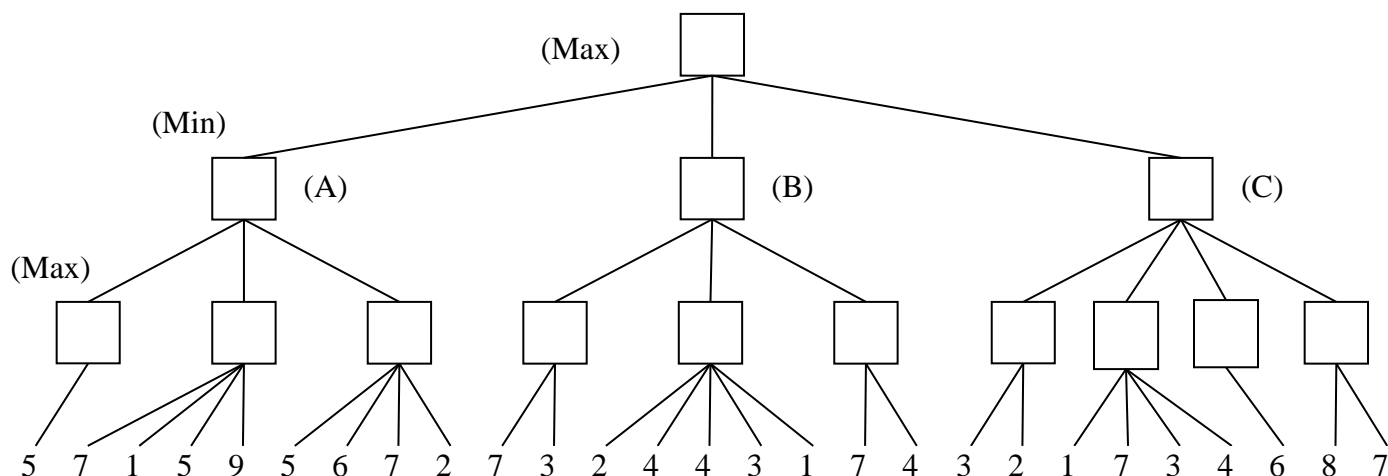
3. (5 pts total, -1 pt for each error, but not negative) MINI-MAX SEARCH IN GAME TREES.

The game tree below illustrates a position reached in the game. Process the tree left-to-right. It is **Max**'s turn to move. At each leaf node (number at bottom) is the estimated score returned by the heuristic static evaluator.

3.a. Fill in each blank square with the proper mini-max search value.

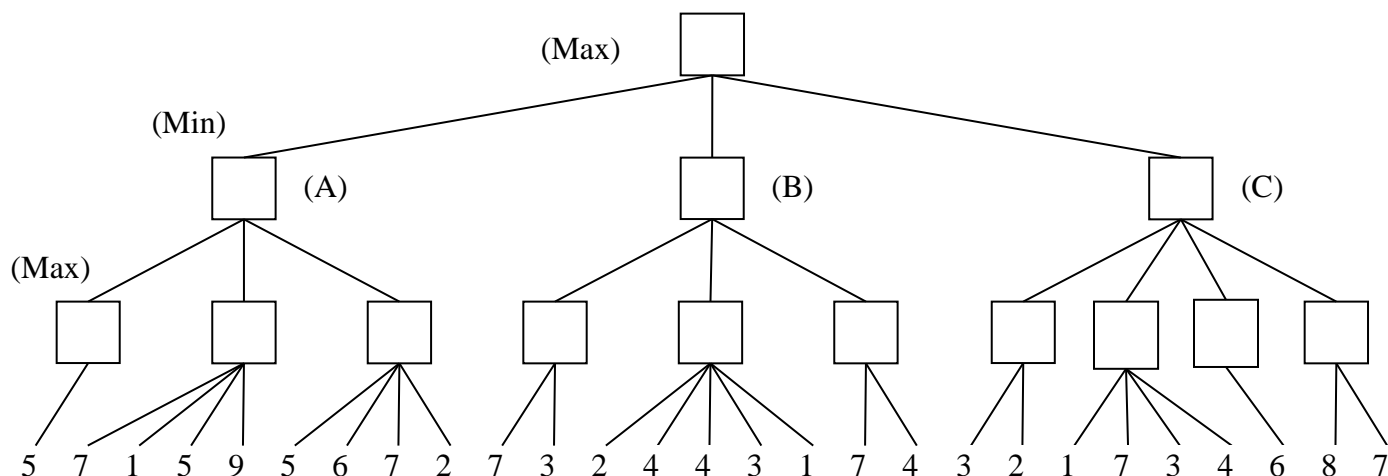
3.b. What is the best move for Max? (write A, B, or C) _____

3.c. What score does Max expect to achieve? _____



4. (10 pts total, -1 for each error, but not negative) ALPHA-BETA PRUNING. Process the tree left-to-right. This is the same tree as above (3.a). You do not need to indicate the branch node values again (but you may do so if you wish).

Draw X over each leaf node (number at bottom) that will be pruned by Alpha-Beta Pruning.



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5. (6 pts total, 1 pt each) Logic Concepts. Match each term or phrase on the left to the best correspondence on the right. **The first one is done for you as an example.**

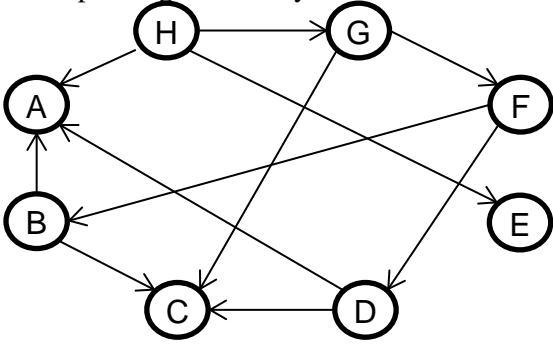
A .	Logic	A	Formal symbol system for representation and inference
	Valid	B	The idea that a sentence follows logically from other sentences
	Complete	C	True in every possible world
	Conjunctive Normal Form	D	True in at least one possible world
	Sound	E	A sentence expressed as a conjunction of clauses (disjuncts)
	Satisfiable	F	Inference system derives only entailed sentences
	Entailment	G	Inference system can derive any sentence that is entailed

6. (12 pts total, 1 pt each) Properties of task environments. For each of the following terms or phrases on the left, write in the letter corresponding to the best answer or the correct definition on the right. **The first one is done for you as an example.**

A	Agent	A	Perceives environment by sensors, acts by actuators
	Episodic	B	Sensors give complete state of environment at each time point
	Discrete	C	More than one agent in the task environment
	Static	D	Next state is exactly determined by current state and agent action
	Sequential	E	The current decision could affect all future decisions
	Semidynamic	F	Environment can change while the agent is deliberating
	Deterministic	G	Finite number of states, percepts, and actions
	Fully observable	H	The outcomes (or probabilities) for all actions are given
	Uncertain	I	Environment does not change while the agent is deliberating
	Known	J	Environment does not change while the agent is deliberating, but its performance measure does
	Multiagent	K	A series of atomic episodes, each independent of prior agent actions
	Stochastic	L	Next state not exactly determined by current state and agent action
	Dynamic	M	Not fully observable or not deterministic

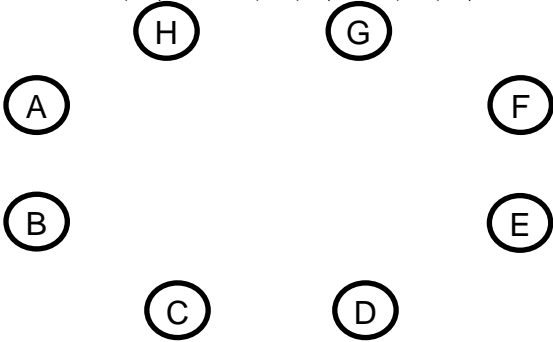
7. (15 pts total, 5 pts each) BAYESIAN NETWORKS.

7.a. (5 pts total, -1 for each error, but not negative) Write down the factored conditional probability expression corresponding to this Bayesian Network:

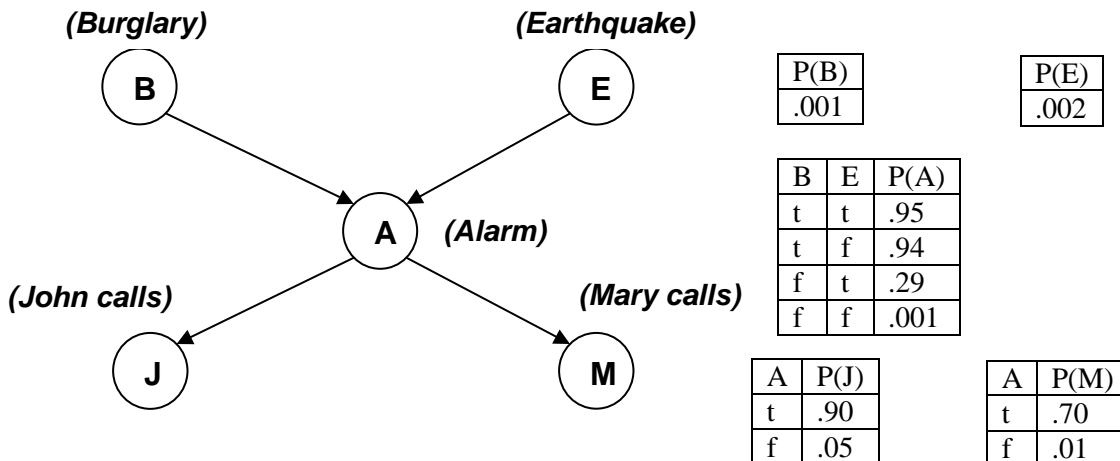


7.b. (5 pts, -1 for each error, but not negative) Draw the Bayesian Network corresponding to this factored conditional probability expression:

$$P(A | C, D, F) P(B | D, G) P(C | F, G, H) P(D | E) P(E | G, H) P(F | G, H) P(G | H) P(H)$$



7.c. (5 pts, -1 for each error, but not negative) Shown below is the Bayesian network corresponding to the Burglar Alarm problem, i.e., $P(J, M, A, B, E) = P(J | A) P(M | A) P(A | B, E) P(B) P(E)$. This is Fig. 14.2 in your R&N textbook. The probability tables show the probability that a boolean random variable is true. For example, $P(J=t|A=t)$ is 0.9 and so $P(J=f|A=t)$ is $1 - 0.9 = 0.1$.



Write down an expression that will evaluate to $P(J=t \wedge M=t \wedge A=f \wedge B=f \wedge E=t)$. Express your answer as a series of numbers (numerical probabilities) separated by multiplication symbols. You do not need to carry out the multiplication to produce a single number (probability).

$$P(J=t \wedge M=t \wedge A=f \wedge B=f \wedge E=t) =$$

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8. (7 pts total, 1 pt each) The Knowledge Engineering process.

Your book identifies seven sequential steps in the knowledge engineering process, which steps are below. Unfortunately, the order of the steps has been scrambled. Please, straighten them out.

- A. Encode a description of the specific problem instance
- B. Assemble the relevant knowledge
- C. Pose queries to the inference procedure and get answers
- D. Encode general knowledge about the domain
- E. Debug the knowledge base
- F. Identify the task
- G. Decide on a vocabulary of predicates, functions, and constants

Fill in the blanks with the letters A, B, C, D, E, F, and G, all in the proper sequence.

_____.

9. (6 pts total, 1 pt each) Logic-To-English. For each of the following FOPC sentences on the left, write the letter corresponding to the best English sentence on the right. Use these intended interpretations: (1) “Student(x)” is intended to mean “x is a student.” (2) “Quiz(x)” is intended to mean “x is a quiz.” (3) “Got100(x, y)” is intended to mean “x got 100 on y.”

$\forall s \exists q \text{ Student}(s) \Rightarrow [\text{Quiz}(q) \wedge \text{Got100}(s, q)]$	A	For every quiz, there is a student who got 100 on it.
$\exists q \forall s \text{ Quiz}(q) \wedge [\text{Student}(s) \Rightarrow \text{Got100}(s, q)]$	B	For every student, there is a quiz on which that student got 100.
$\forall q \exists s \text{ Quiz}(q) \Rightarrow [\text{Student}(s) \wedge \text{Got100}(s, q)]$	C	Every student got 100 on every quiz.
$\exists s \forall q \text{ Student}(s) \wedge [\text{Quiz}(q) \Rightarrow \text{Got100}(s, q)]$	D	Some student got 100 on some quiz.
$\forall s \forall q [\text{Student}(s) \wedge \text{Quiz}(q)] \Rightarrow \text{Got100}(s, q)$	E	There is a quiz on which every student got 100.
$\exists s \exists q \text{ Student}(s) \wedge \text{Quiz}(q) \wedge \text{Got100}(s, q)$	F	There is a student who got 100 on every quiz.

10. (9 pts total, 1 pt each) Probability concepts and formulae. Match each term or phrase on the left to the best correspondence 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	Degree of belief accorded without any other information
	Independence	C	Degree of belief accorded after some evidence is obtained
	Product rule (chain rule)	D	Gives probability of all combinations of values of all variables
	Conditional probability	E	Takes values from its domain with specified probabilities
	Unconditional probability	F	$P(A) = \sum_B P(A, B)$
	Sum Rule	G	$P(a \wedge b) = P(a) P(b)$
	Random variable	H	$P(a \wedge b \mid c) = P(a \mid c) P(b \mid c)$
	Bayes' rule	I	$P(a \mid b) = P(b \mid a) P(a) / P(b)$
	Joint probability distribution	J	$P(a \wedge b \wedge c) = P(a \mid b \wedge c) P(b \mid c) P(c)$

**** THIS IS THE END OF THE MID-TERM 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