CS-E4800 Artificial Intelligence | **Full Name**: ______________________
Spring 2022 | **Student ID**: ______________________
Exam April 14, 2022 | **Signature**: ______________________

Answer yes-no questions by marking "✓" in the respective boxes "☐". If you are unable to answer a question you may leave it unanswered (worth 0p). Return an additional sheet that includes your calculations/reasoning to justify your answers for Q4, Q5, Q7 and Q8.

Question 1(20 p): Are the following claims correct? (each item: **correct: 4p, wrong: -4p**)

(a) Runtime of A* is linearly proportional to the length of shortest optimal solutions. ☐ **Yes** ☐ **No**
(b) Amount of memory used by breadth-first search is linear in the length of the shortest solution. ☐ **Yes** ☐ **No**
(c) If h_1 and h_2 are admissible heuristics, then so is $h(x) = \max(h_1(x), h_2(x))$. ☐ **Yes** ☐ **No**
(d) The sum of two PDB distance estimates is always an admissible heuristic. ☐ **Yes** ☐ **No**
(e) For the distance from a node at (x_0, y_0) to a node at (x_1, y_1) on a graph-like map, $\frac{|x_0-x_1|+|y_0-y_1|}{2}$ is admissible. ☐ **Yes** ☐ **No**

Question 2 (20 p) Yes or no? Give a very short "formal" justification (e.g. valuation or structure, short proof, ...)

1. $a \vee b$ is logically equivalent to $\neg(\neg b \wedge \neg a)$. ☐ **Yes** ☐ **No**
2. $\forall x \exists y.P(x, y) \models \exists x \forall y.P(x, y)$ ☐ **Yes** ☐ **No**

Question 3 (20 p) Within an on-line home exercise system, a student attempts to find the correct answers to a sequence of three yes-no questions by trial and error, without initially knowing the answers. The system indicates how many answers were correct, but not which ones. The student's initial guess is NO, YES, NO (NYN), for which the website gives him $2/3$ points (2 correct out of 3). His second attempt is NYY, which yields $1/3$ points. His third attempt is YYN, which also yields $1/3$ points. Record the student's belief states after these three guesses on the right.

guess 1	
guess 2	
guess 3	

Question 4 (20 p) Consider a system that has two states s_0 and s_1. Let the belief state B be such that $B(s_0) = 0.7$ and $B(s_1) = 0.3$. Now an observation O is made, with $P(O|s_0) = 0.8$ and $P(O|s_1) = 0.1$, leading to a new belief state B'. Indicate the probabilities of s_0 and s_1 for B' in the table.

$B'(s_0) =$	
$B'(s_1) =$	

Question 5 (20 p) Consider the following normal form game.

	Q	R
A	$1, -4$	$0, 0$
B	$0, 0$	$4, -1$

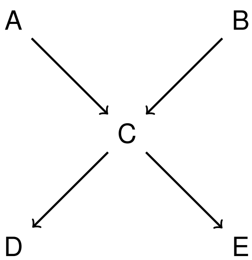
If the players are rational, and their rationality is common knowledge to both players, and both players know all aspects of the game, what strategies would be played? Indicate the probabilities of strategies A and B for the row player and the probabilities of strategies Q and R for the column player.

A	
B	
Q	
R	

Question 6 (20 p) Formalize in the predicate logic the concept of (first) *cousin* on the basis of the primitive concept *parent*.

Question 7 (20 p) In this Bayesian net, what is the probability of $\neg A \wedge B \wedge \neg C \wedge E$?

$P(\neg A \wedge B \wedge \neg C \wedge E) =$



$P(A)$
0.3

$P(B)$
0.9

C	$P(D\|C)$
0	0.9
1	0.8

A	B	$P(C\|A,B)$
0	0	0.9
0	1	0.8
1	0	0.0
1	1	0.2

C	$P(E\|C)$
0	0.4
1	0.5

Question 8 (20 p) Consider a Markov decision process with two states R and S. The transition probabilities of the two actions are given by the following matrices.

	R	S
R	0.8	0.2
S	1.0	0.0

	R	S
R	0.0	1.0
S	1.0	0.0

For the first action, the immediate reward is 3 for state S and 0 for state R. For the second action, the immediate reward is 0 for both states.
Perform three iterations of Value Iteration with discount factor $\gamma = 0.5$. The starting point is the value function V_0 such that $V_0(R) = 0$ and $V_0(S) = 0$. Calculate the value functions V_1, V_2 and V_3, and record the values $V_i(R)$ and $V_i(S)$ in the table.

	R	S
V_0	0	0
V_1		
V_2		
V_3		