Examination, April 15, 2021
Wrong answers to yes/no questions will give half the points negatively, e.g. for a 2-point question this means -1 points. If you are not sure about the answer, it's best to answer 'DontKnow'! Answers to numeric questions 'close enough' will yield full points, and answers a bit off still yield some points.
Question 1 ( 10.00 pts ) Consider the following two games.

|  | $C$ | $D$ |
| :---: | :---: | :---: |
| $A$ | $5,-3$ | 0,1 |
| $B$ | $1,-1$ | $4,-4$ |


|  | $G$ | $H$ |
| :---: | :---: | :---: |
| $E$ | 5,0 | $2,-4$ |
| $F$ | $-1,-7$ | $-3,9$ |

Both games have exactly one Nash equilibrium (either in pure or in mixed strategies). Find those Nash equilibria. What are the probabilities of playing the strategies A, C, E and G? Return your answer as the vector $(P(A), P(C), P(E), P(G))$.
Question 2 (12.00 pts) Consider the following Bayesian network and the CPTs for all nodes.


Answer the following questions.
(a) What is the conditional probability $P(B \mid \neg A, \neg C)$ ?
(b) What is the probability $P(C)$ ?
(c) What is the probability $P(\neg A, \neg B, \neg C)$ ?

Question 3 ( 8.00 pts ) True or false?
(a) IDA* never performs more search steps than $\mathrm{A}^{*}$.
(b) For a network on the Euclidian plane, the Manhattan distance can over-estimate the cost of the shortest path at most by a factor of $\sqrt{2}$.
(c) The breadth-first search algorithm is guaranteed to find a solution with the lowest possible cost if all arc costs are the same.
(d) The WA* algorithm with $W=3$ performs at most $\frac{1}{3}$ of the expansions performed by A*.

Question 4 ( 10.00 pts ) Consider the following structure.

```
universe }U={1,2,3,4
constant }a=
constant b}=
predicate Q = {1}
predicate P}={(1,2),(2,2),(2,3)
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Which of the following formulas are true in this structure?
(a) $\exists x(Q(x) \vee \forall y P(x, y))$
(b) $\exists y \forall x P(x, y) \rightarrow \forall x \exists y P(x, y)$
(c) $\forall x \exists y(Q(x) \rightarrow Q(y))$
(d) $\forall x(\exists y P(x, y) \vee \exists y P(y, x))$

Question 5 ( 10.00 pts ) The current belief state is $(0.40,0.60)$. It assigns the given probabilities respectively to states $s_{0}, s_{1}$. Now we observe obsl. The observation probabilities are $P\left(o b s 1 \mid s_{0}\right)=0.45, P\left(o b s 1 \mid s_{1}\right)=0.10$. Compute the new belief state after the observation.
Question 6 ( 10.00 pts ) Which of the following claims hold?
(a) $(J \rightarrow K) \wedge(\neg J \rightarrow L) \wedge \neg(K \wedge L)$ is satisfiable.
(b) $(A \vee \neg B) \wedge(B \vee \neg A)$ is satisfiable.
(c) $\neg K \rightarrow L \models L \rightarrow \neg K$
(d) $K \rightarrow(L \rightarrow K)$ is valid.
(e) $E \rightarrow F \models G \rightarrow(E \rightarrow F)$

Question 7 ( 10.00 pts ) Consider the following Markov decision process.

- States: $s_{0}, s_{1}$
- Actions: act1, act2
- Transitions: $P\left(s_{0}\right.$, act $\left.1, s_{1}\right)=1.00, P\left(s_{1}\right.$, act $\left.1, s_{1}\right)=0.30, P\left(s_{1}\right.$, act $\left.1, s_{0}\right)=0.70, P\left(s_{0}\right.$, act $\left.2, s_{1}\right)=1.00$, $P\left(s_{1}\right.$, act $\left.2, s_{0}\right)=1.00$
- Rewards: $R\left(s_{0}\right.$, act $\left.2, s_{1}\right)=3.00$, and rewards for other transitions are 0.0 .
- $\gamma=0.90$

Run the Value Iteration algorithm for 3 rounds starting from the initial value function $V_{0}$ in which all states have value 0 (represented by the vector $(0,0)$ ). Return the value functions $V_{1}, V_{2}, V_{3}$.

## Exam Rules

1. Any communication with other people by any means is not allowed.
2. You are allowed to use the CS-E4800 course material and general sources such as Wikipedia or the RussellNorvig textbook.
3. Use of calculator is allowed.

## Grading

Maximum from the exam is $10.00+12.00+8.00+10.00+10.00+10.00+10.00=\mathbf{7 0 . 0 0}$ points. These points are not directly comparable to the exercise points, and will be scaled and aggregated with the exercise points to determine the course grade.

