CptS 440/540 – Artificial Intelligence
Fall 2020

Exam II

November 5, 2020, 9:10am-10:25am, Pacific time

Instructions (read carefully):

1. This exam has 8 questions and 8 pages.
2. You must submit a single PDF file with your responses to the exam questions on Blackboard Learn by 10:25am pacific time on November 5, 2020.
3. If your submission is late, as determined by the Blackboard Learn timestamp, then you will be deducted 1 point for each minute your exam is late. *This will be strictly enforced*. The exam is worth 60 points and is designed to be completed in 1 hour (if you studied). This leaves 15 minutes to access the exam and upload your response; please plan accordingly.
4. The exam is open book and open notes, and you may use a calculator. You may not receive any assistance during the exam from other people or the Internet. Evidence of assistance will result in a zero on the exam. If you have questions during the exam, you may email me at holder@wsu.edu. I will be monitoring my email during the exam and will respond as soon as possible.
5. Your exam response can be created with an editor on your computer and/or scans or pictures of a written response. Make sure all responses are clearly legible and that the exam question number is clearly indicated. Again, your exam response must be a single PDF file.

1. Clearly print your full name and your WSU ID number.

2. Take a picture of yourself holding your WSU ID card right-side up. Your full face and your card's name, photo, and ID number should be clearly visible in the picture. Include the picture in your PDF response. *Your exam will not be graded without this picture included*.

3. (10 points) Consider the following first-order logic predicates.

- Breeze(x,y): there is a breeze in location (x,y)
- Pit(x,y): there is a pit in location (x,y)
- Stench(x,y): there is a stench in location (x,y)
- Wumpus(x,y): the Wumpus is in location (x,y)
- Agent(x,y): the agent is in location (x,y)
- Safe(x,y): location (x,y) is safe

Convert the following English sentences into first-order logic using only the above predicates.

a. (2 points) There is at least one Safe location.

b. (2 points) There is either a Breeze or a Stench (or both) in location (2,2).

c. (3 points) The Wumpus and the Agent are never in the same location.

d. (3 points) A location is safe if it does not contain the Wumpus or a Pit.

4. (10 points) Convert the following first-order logic sentences into Conjunctive Normal Form. There is no need to show intermediate steps.

    a. (2 points) $\exists x,y$ Stench(x,y)

    b. (2 points) $\forall x,y$ Wumpus(x,y) $\Rightarrow \neg$Safe(x,y)

    c. (3 points) $\forall x,y$ (Breeze(x,y) $\Rightarrow \exists w,z$ Pit(w,z))

    d. (3 points) $\forall x$ (Foo(x) $\vee$ Bar(x)) $\Rightarrow$ Baz(x)

5. (10 points) Given the following knowledge base, already expressed in CNF, use resolution by refutation to prove Dead(Agent) is true. Show each resolution step by indicated the two clauses being resolved (be sure to use unique variable names for each clause), the resulting clause (give it a new number), and any necessary variable substitutions. Also be sure to conclude your proof with a statement of what was proven.

C1: ¬Pit(x,y) ∨ Safe(x,y)
C2: Safe(x,y) ∨ ¬Agent(x,y) ∨ Dead(Agent)
C3: Pit(3,3)
C4: Agent(3,3)

6. (9 points) Suppose you are given the following full joint probability distribution over three Boolean random variables: *Breeze*, *Stench*, *Safe*. Compute the probabilities below. Show your work. *Your final answers should be real numbers – no incomplete arithmetic or fractions*.

	Breeze:	true		false	
	Stench:	true	false	true	false
Safe:	true	0.05	0.10	0.08	0.25
	false	0.20	0.20	0.08	0.04

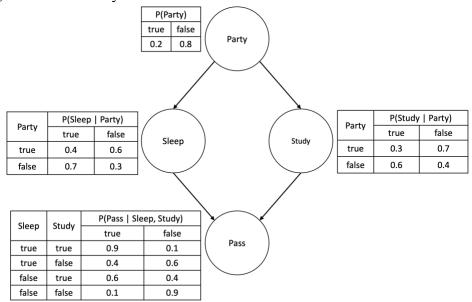   a. (2 points) P(Breeze=true, Stench=true).

    b. (3 points) P(Safe=true | Breeze=false, Stench=false).

    c. (4 points) P(Safe=false | Breeze=true).

7. (6 points) Suppose we have two Boolean random variables Rain and Cloudy, and we know the following probabilities:

- P(Rain=true | Cloudy=true) = 0.4
- P(Rain=true | Cloudy=false) = 0.1
- P(Cloudy=true) = 0.2

Compute P(Cloudy=true | Rain=true). Show your work. *Your final answer should be a real number – no incomplete arithmetic or fractions.*

8. (15 points) Consider the Bayesian network below.

P(Party)	
true	false
0.2	0.8

Party

Party	P(Sleep | Party)	
	true	false
true	0.4	0.6
false	0.7	0.3

Sleep

Study

Party	P(Study | Party)	
	true	false
true	0.3	0.7
false	0.6	0.4

Sleep	Study	P(Pass | Sleep, Study)	
		true	false
true	true	0.9	0.1
true	false	0.4	0.6
false	true	0.6	0.4
false	false	0.1	0.9

Pass

   a. (5 points) What is the most probable sample from the above network and what is its probability?

   b. (10 points) Compute the P(Party=true | Pass=true). Show your work. *Your final answer should be a real number – no incomplete arithmetic or fractions.*