CptS 440/540 – Artificial Intelligence
Fall 2020

Exam II

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

Note: The Fall 2021 exam will be administered as a Quiz on Canvas.

1. 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. There is at least one Safe location.

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

   c. The Wumpus and the Agent are never in the same location.

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

2. Convert the following first-order logic sentences into Conjunctive Normal Form. There is no need to show intermediate steps.

    a. $\exists x,y\ \text{Stench}(x,y)$

    b. $\forall x,y\ \text{Wumpus}(x,y) \Rightarrow \neg\text{Safe}(x,y)$

    c. $\forall x,y\ (\text{Breeze}(x,y) \Rightarrow \exists w,z\ \text{Pit}(w,z))$

    d. $\forall x\ (\text{Foo}(x) \vee \text{Bar}(x)) \Rightarrow \text{Baz}(x)$

3. 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: $\neg$Pit(x,y) $\vee$ $\neg$Safe(x,y)
C2: Safe(x,y) $\vee$ $\neg$Agent(x,y) $\vee$ Dead(Agent)
C3: Pit(3,3)
C4: Agent(3,3)

4. 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. P(Breeze=true, Stench=true).

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

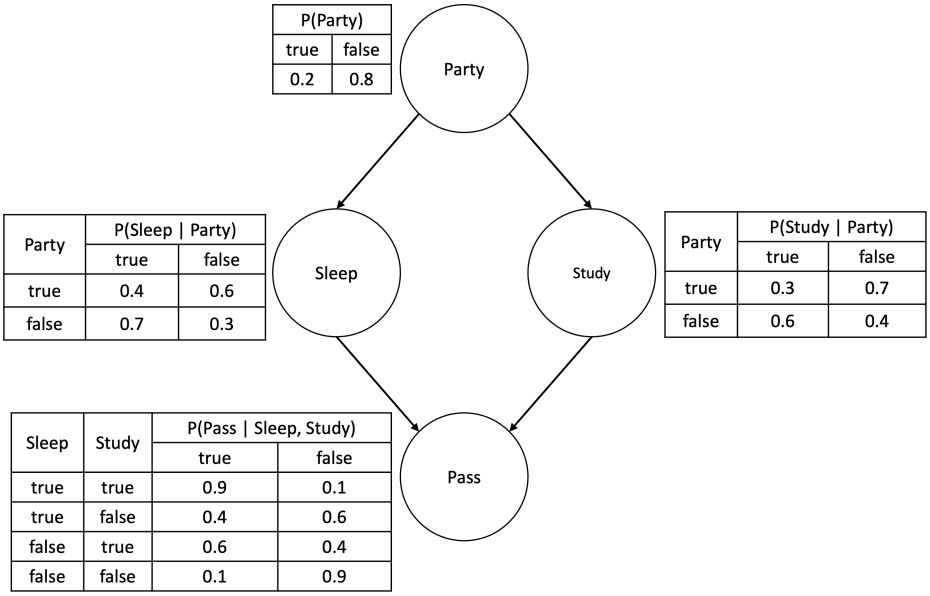
c. P(Safe=false | Breeze=true).

5. 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*.

6. Consider the Bayesian network below.



P(Party)	
true	false
0.2	0.8

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

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

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

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