TUFTS UNIVERSITY
Department of Computer Science

CS 131 | Artificial Intelligence | Summer 2022
Midterm Exam 02 | 05–09 August 2022

- **Please sign your name below (or write it to the top of each page of your work, if you are not solving on the exam paper). By doing so, you agree to be bound by Tufts policies on academic integrity.**
- **For this exam, you may use any notes you have taken, the Russell & Norvig text, and any materials distributed by the instructor (including lecture notes/videos and code samples). No other materials are to be used.**
- **This booklet contains 7 pages including the cover page.**
- **You have exactly 105 minutes (one hour, 45 minutes) to complete this exam *and* upload a PDF version to Gradescope. Be sure to leave yourself enough time for the latter steps.**
- **The maximum possible is 50.**

PROBLEM	SCORE
1	
2	
3	
4	
TOTAL	

NAME: _____

1. **(9 pts.) TRUE OR FALSE.**

Indicate whether each of the following sentences is true or false, and provide a brief explanation.

a. (3 pts.) (T ___ F ___) Suppose that X and Y *are not* independent. This means that $P(X \mid Y) < P(X)$.

b. (3 pts.) (T ___ F ___) Suppose that X and Y *are* independent. This means that, for any variable Z, $P(Z \mid X, Y) = P(Z \mid X)P(Z \mid Y)$.

c. (3 pts.) (T ___ F ___) When compared to the full joint probability distribution, a Bayes Net will use fewer numbers to calculate the probabilities that it represents.

2. **(13 pts.) BASIC PROBABILITY.**

The Boston Red Sox are down 3 runs in the 8th inning of a playoff game against the Tampa Bay Rays. Statisticians tell us that there is only a 0.04 probability that they will win the game.

a. The statisticians also say that the chance of a Red Sox win increases to 0.5 if the next two players to bat for Boston hit home runs. These players are Devers and Bogaerts.

   i. (2 pts.) The probability that Devers hits a home run is 0.2; the probability for Bogaerts is 0.1. If each hitter's performance is independent of the other, what is the probability that they *both* hit home runs? In your calculations, use D for the event that Devers hits a home run and use B for the even that Bogaerts does; show all work.

   ii. (5 pts.) Tired and frustrated, you go to bed. When you wake up, you see on NESN that the Red Sox did win the game. Knowing that, what is the probability that Devers and Bogaerts both hit home runs? In your calculations, use D and B as before, and use W for the event that Boston wins the game; show all work.

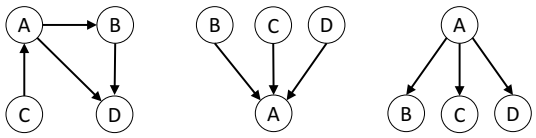
(*Problem continued on next page*)

b. (6 pts.) In the same situation described before, we are given that Boston only has an overall probability of 0.04 of winning the game, and we know that if both Devers and Bogaerts hit home runs, that probability increases to 0.5. Based on this information, and the probability that both hit a home run (as calculated in the first part of this question), what is the probability that Boston wins if this *does not* happen?

Note: Use the same notation as before and show all your work. The final answer can be worked out based on conditionalization and elementary algebra.

3. **(10 pts.) BAYES NETS (I).**

Consider the Bayesian networks shown below. All variables are Boolean (true/false).



a. (2 pts.) Which network version has fewest parameters? How many does it have?

b. (3 pts.) For each of the networks is it true or false that $P(C \mid A, D) = P(C \mid A)$, i.e., C is independent of D, given A? in each case, justify your answer using d-separation.

1.

2.

3.

c. (5 pts.) Express $P(D \mid C)$ in terms of probabilities directly available in the network, **using network 1**. Show your work and simplify your answer as much as you can.

4. **(18 pts.) BAYES NETS (II).**

Homer Simpson is building a Bayes net to help manage the Springfield Nuclear Power Plant. He reasons this way: there are two main things that can affect the amount of activity in the nuclear core: (a) the amount of power being used in Springfield at the time, and (b) whether or not the plant is suffering a meltdown.

There are three possible levels of power use in Springfield (*High*, *Medium*, and *Low*), and the nuclear core also has three levels of activity (*Active*, *Normal*, and *Dormant*). We can assume that whether or not the plan is suffering a meltdown is a boolean variable. Homer has a dial with three colors on it (*Red*, *Green*, and *Blue*) that he can use to monitor the activity in the nuclear core; the dial is not a perfect indicator, and so the various colors provide only imperfect evidence about the state of the core. He also has a donut; this donut will sometimes start to glow if a meltdown is occurring.

a. (6 pts.) Draw a Bayes Net for this problem. (Just draw the nodes and arrows, **not** the Conditional Probability Tables.)

(*Problem continued on next page.*)

b. (4 pts.) Give the full CPT for the nuclear core activity node. (You can use any numbers you think are reasonable, but your CPT must have the correct number of values in it, and no more than are needed.)

c. (4 pts.) In your BN, is the value of the variable for the dial independent of whether a meltdown is happening? If so, why is that true? If not, what evidence would make those nodes conditionally independent?

d. (4 pts.) In your BN, is the value of the meltdown variable independent of the amount of power use in Springfield? If so, why is that true? If not, what evidence would make those nodes conditionally independent?