Name: _____

CptS 440/540 – Artificial Intelligence
Fall 2017

Exam II

November 2, 2017, 9:10am-10:25am

Duration: 75 minutes

Instructions: Clearly write your name at the top of this exam. Complete all problems on this exam. Write all your work on this exam; you may use the backs of pages if needed. The exam is closed book, closed notes, and closed neighbor. No electronic devices are allowed, except your own calculator. Failure to turn in your exam at the end of 75 minutes will result in deduction of points. Anyone cheating on the exam will receive a zero.

Problem	Points Possible	Your Score
1	12	
2	10	
3	12	
4	10	
5	15	
6	10	
7	6	
Total	75	

1. (12 points) Translate each of the following English sentences into first-order logic using only the following predicates.

   Animal(x,y): true if object x is an animal of type y, where $y \in$ {Dog, Fox, Wumpus}
   JumpsOver(x,y): true if object x jumps over object y.

   a. (1 point) Scooby is a dog.

   b. (2 points) There is at least one fox.

   c. (3 points) There is a fox that jumps over every dog.

   d. (3 points) Every dog is jumped over by at least one fox.

   e. (3 points) Nothing jumps over a wumpus.

2. (10 points) Convert each of the following first-order logic statements into conjunctive normal form (CNF).

   a. (1 point) $\neg$ Animal(Scooby,Wumpus)

   b. (2 points) $\neg \exists x$ JumpsOver(x,x).

   c. (3 points) $\forall x,y,z$ JumpsOver(x,y) $\wedge$ JumpsOver(y,z) $\Rightarrow$ JumpsOver(x,z)

   d. (4 points) $\forall x$ Animal(x,Dog) $\vee$ Animal(x,Fox) $\Rightarrow \exists y$ JumpsOver(y,x)

3. (12 points) Consider the following knowledge base.

   Animal(Willy,Wumpus)
   $\neg$ Animal(Swiper,Wumpus)
   $\neg$ Animal(Swiper,Dog)
   $\forall x,y$ Animal(x,Wumpus) $\wedge$ Animal(y,Fox) $\Rightarrow$ JumpsOver(x,y)
   $\forall x$ $\neg$ Animal(x,Dog) $\wedge$ $\neg$ Animal(x,Wumpus) $\Rightarrow$ Animal(x,Fox)

   a. (5 points) Convert the knowledge based to clausal form. Give each clause a number.

b. (7 points) Using the knowledge base from part (a), perform a resolution proof by refutation to prove JumpsOver(Willy,Swiper). For each resolution step, indicate the two clauses involved, the resulting clause, and any substitutions needed. Be sure to uniquify variables.

4. (10 points) Given the following full joint probability distribution, answer the questions below. Show your work.

	HaveCold=true		HaveCold=false	
	RunnyNose=true	RunnyNose=false	RunnyNose=true	RunnyNose=false
SoreThroat=true	0.07	0.04	0.09	0.15
SoreThroat=false	0.04	0.02	0.22	0.37

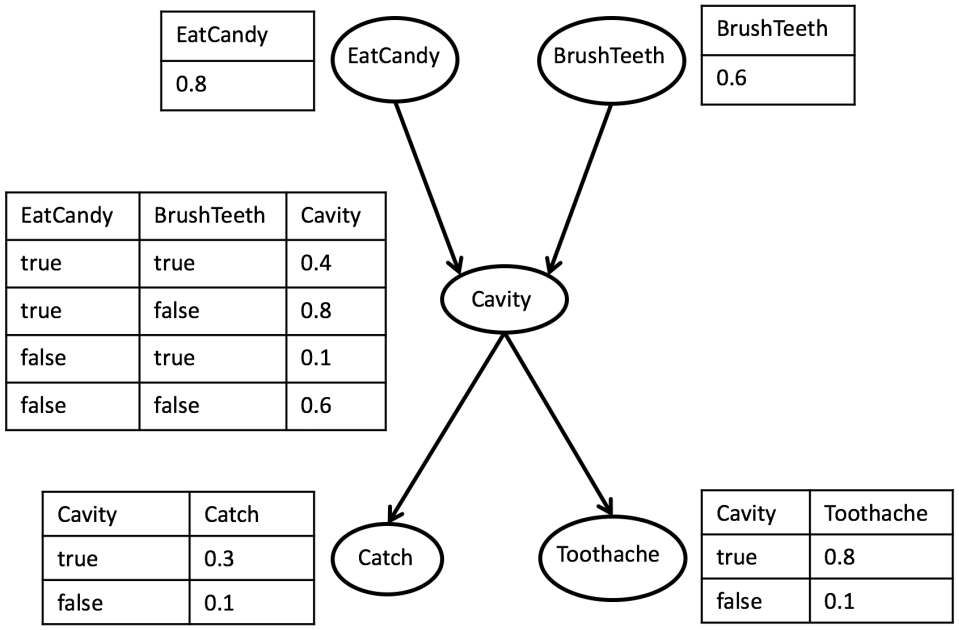
a. (2 points). P(HaveCold=true).

b. (2 points). P(HaveCold=true, RunnyNose=true, SoreThroat=true).

c. (3 points). P(HaveCold=true | RunnyNose=true).

d. (3 points). P(HaveCold=true | RunnyNose=true, SoreThroat=true).

5. (15 points) Consider the following Bayesian network.



EatCandy
0.8

BrushTeeth
0.6

EatCandy	BrushTeeth	Cavity
true	true	0.4
true	false	0.8
false	true	0.1
false	false	0.6

Cavity	Catch
true	0.3
false	0.1

Cavity	Toothache
true	0.8
false	0.1

a. (4 points). Show the most likely sample generated from this network using direct sampling, and compute its probability.

b. (4 points). Compute P(Cavity=true). Show your work.

c. (7 points). Compute P(EatCandy=true | Toothache=true). Show your work.

6. (10 points) Suppose you want to add a sixth random variable, called ChewIce, to the Bayesian network in Problem 5. Based on the following information, draw the topology of the new Bayesian network and include only the conditional probability tables that change.
    - P(EatCandy | ChewIce) = P(EatCandy)
    - P(BrushTeeth | ChewIce) = P(BrushTeeth)
    - P(Cavity | EatCandy, BrushTeeth, ChewIce) = P(Cavity | EatCandy, BrushTeeth)
    - P(Catch | Cavity, ChewIce) = P(Catch | Cavity)
    - P(Toothache | Cavity, ChewIce) ≠ P(Toothache | Cavity)
    - P(Toothache | Cavity=true, ChewIce=true) = 0.9
    - P(Toothache | Cavity=true, ChewIce=false) = 0.8
    - P(Toothache | Cavity=false, ChewIce=true) = 0.2
    - P(Toothache | Cavity=false, ChewIce=false) = 0.1
    - P(ChewIce | EatCandy, BrushTeeth, Cavity, Catch, Toothache) = P(ChewIce)
    - P(ChewIce=true) = 0.3

7. (6 points) Consider a 4x4 wumpus world, where the agent has visited locations (1,1), (1,2), (2,1) and (2,2). The agent has observed the following evidence E = {$Pit_{1,1}$=false, $Pit_{1,2}$=false, $Pit_{2,1}$=false, $Pit_{2,2}$=false, $Breeze_{1,1}$=false, $Breeze_{1,2}$=true, $Breeze_{2,1}$=true, $Breeze_{2,2}$=true}. As usual, the prior probability a location other than (1,1) has a pit is 0.2. Based on this information, compute P($Pit_{3,2}$=true | E). Show your work.