

**Name: Madhushalini Murali    CWID: A20513784**

**CS 480 Fall 2022 Written Assignment #03**

**Due: Sunday, November 6, 11:00 PM CST**

**Points: 45**

**Instructions:**

1. Use this document template to report your answers. Name the complete document as follows:

LastName\_FirstName\_CS480\_Written03.doc or pdf

2. Submit the final document to Blackboard Assignments section before the due date. No late submissions will be accepted.

**Objectives:**

1. (25 points) Demonstrate your understanding of First-Order Logic syntax.
2. (20 points) Demonstrate your understanding of Bayes' Rule.

**Problem 1 [25 pts]:**

Convert English sentences to FOL. Write each of the following English sentences using First Order Logic. Use the following predicates and constants only.

- n Position(**x**, **y**): Predicate. Person **x** has position **y**. You can also read it as **x** holds **y** or **x** is **y**.
- n Friend(**p1**, **p2**): Predicate. Person **p1** is a friend of person **p2**.
- n WorksFor(**z1**, **z2**): Predicate. Person **z1** works for person **z2**.
- n Professor, Judge, Footballer, Athlete: Constants denoting some positions. This list is not comprehensive. **There are also other positions not mentioned here.**

n Chris, Penelope: Constants denoting some people. This list is not comprehensive. There are also other people not mentioned in this list.

a) Penelope is neither a professor nor a footballer [5 pts].

**Your solution:**

$\neg \text{Position}(\text{Penelope}, \text{Professor}) \wedge \neg \text{Position}(\text{Penelope}, \text{Footballer})$

b) Chris is not a professor and he works for no one [5 pts].

**Your solution:**

$\neg \text{Position}(\text{Chris}, \text{Professor}) \wedge \neg \forall x \text{ WorksFor}(\text{Chris}, x)$

c) Not all athletes are footballers [5 pts].

**Your solution:**

$(\neg \forall x \text{ Position}(x, \text{Athletes}) \Rightarrow \text{Position}(x, \text{Footballer}))$

d) Chris does not work for any of Penelope's friends [5 pts].

**Your solution:**

$\forall x \text{ Friend}(x, \text{Penelope}) \Rightarrow \neg \text{WorksFor}(\text{Chris}, x)$

- e) Being a judge sometimes means that you have friends **[5 pts]**.

**Your solution:**

$\text{Position}(x, \text{judge}) \wedge \exists y \text{ Friend}(x, y)$

**Problem 2 [20 pts]:**

We are given the following joint distribution for variables A, B, and C. Please compute the requested probabilities. **Show each probability distribution as a table/vector.**

A	B	C	P(A, B, C)
T	T	T	0.014
T	T	F	0.126
T	F	T	0.012
T	F	F	0.048
F	T	T	0.392
F	T	F	0.168
F	F	T	0.144
F	F	F	0.096

a)  $P(A, C)$  [5 pts]

**Solution:**

$P(A, C)$

A	C	SOLUTION	$P(A, C)$	
T	T	$(A = T, B = T, C = T) + (A = T, B = F, C = T)$ $0.014 + 0.012$	0.026	
T	F	$(A = T, B = T, C = F) + (A = T, B = F, C = F)$ $0.126 + 0.048$	0.174	
F	T	$(A = F, B = T, C = T) + (A = F, B = F, C = T)$ $0.392 + 0.144$	0.536	
F	F	$(A = F, B = T, C = F) + (A = F, B = F, C = F)$ $0.168 + 0.096$	0.264	

b)  $P(C)$  – you can use your answer to part a to compute the answer to this question. [5 pts]

**Solution:**

C	SOLUTION	P(C)
T	$(A = T, B = T, C = T) + (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ $0.014 + 0.012 + 0.392 + 0.144$	0.562
F	$(A = T, B = T, C = F) + (A = T, B = F, C = F) + (A = F, B = T, C = F) + (A = F, B = F, C = F)$ $0.126 + 0.048 + 0.168 + 0.096$	0.438

- c)  $P(A|C)$  – you can use your answers to parts a and b to compute the answer to this question.  
[5 pts]

**Solution:**

A	C	SOLUTION	P(A/C)
T	T	$(A = T, B = T, C = T) + (A = T, B = F, C = T) / (A = T, B = T, C = T) + (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ $(0.014 + 0.012) / (0.014 + 0.012 + 0.392 + 0.144)$ $0.026 / 0.562$	0.0462
T	F	$(A = T, B = T, C = F) + (A = T, B = F, C = F) / (A = T, B = T, C = F) + (A = T, B = F, C = F) + (A = F, B = T, C = T) + (A = F, B = F, C = F)$ $(0.126 + 0.048) / (0.126 + 0.048 + 0.168 + 0.096)$ $0.174 / 0.438$	0.397
F	T	$(A = F, B = T, C = T) + (A = F, B = F, C = T) / (A = T, B = T, C = T) + (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ $(0.392 + 0.144) / (0.014 + 0.012 + 0.392 + 0.144)$ $0.536 / 0.562$	0.9537

F	F	$\begin{aligned} & (A = F, B = T, C = T) + (A = F, B = F, C = F) / \\ & (A = T, B = T, C = F) + (A = T, B = F, C = F) + (A = \\ & F, B = T, C = T) + (A = F, B = F, C = F) \\ & (0.168 + 0.096) / (0.126 + 0.048 + 0.168 + 0.096) \\ & 0.264 / 0.438 \end{aligned}$	0.6027
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d)  $P(A, B | C)$  – you can use your answers from previous parts if they are relevant. [5 pts]

<b>Solution:</b>				
<b>A</b>	<b>B</b>	<b>C</b>	<b>SOLUTION</b>	<b><math>P(A, B   C)</math></b>
T	T	T	$(A = T, B = T, C = T) / (A = T, B = T, C = T)$ $+ (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ $0.014 / 0.562$	0.0249
T	T	F	$(A = T, B = T, C = F) / (A = T, B = T, C = F)$ $+ (A = T, B = F, C = F) + (A = F, B = T, C = T) + (A = F, B = F, C = F)$ $0.126 / 0.438$	0.287
T	F	T	$(A = T, B = F, C = T) / (A = T, B = T, C = T)$ $+ (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ $0.012 / 0.562$	0.0213
T	F	F	$(A = T, B = F, C = F) / A = T, B = T, C = F) +$ $(A = T, B = F, C = F) + (A = F, B = T, C = T)$ $+ (A = F, B = F, C = F)$ $0.048 / 0.438$	0.109

F	T	T	$(A = F, B = T, C = T) / (A = T, B = T, C = T)$ $+ (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ 0.392 / 0.562	0.697
F	T	F	$(A = F, B = T, C = T) / (A = T, B = T, C = F)$ $+ (A = T, B = F, C = F) + (A = F, B = T, C = T) + (A = F, B = F, C = F)$ 0.168 / 0.438	0.3835
F	F	T	$(A = F, B = F, C = T) / (A = T, B = T, C = T)$ $+ (A = T, B = F, C = T) + (A = F, B = T, C = T) + (A = F, B = F, C = T)$ 0.144 / 0.562	0.256
F	F	F	$(A = F, B = F, C = F) / (A = T, B = T, C = F)$ $+ (A = T, B = F, C = F) + (A = F, B = T, C = T) + (A = F, B = F, C = F)$ 0.096 / 0.438	0.219

