United International University (UIU)

Dept. of Computer Science & Engineering (CSE)

Final Exam

Course Code: CSI 341 Course Title: Artificial Intelligence

Total Marks: **40** Duration: 2 hours

There are 7 questions. **Answer all questions**. Marks are indicated in the right side of each question.

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1. You are trying to forecast urban air pollution using Markov model. The quality of air can be clear, dirty or mist. The transition probabilities are given in the following table:

Next Day → Today↓	Clear	Dirty	Mist
Clear	0.3	0.5	0.2
Dirty	0.2	0.4	0.4
Mist	0.4	0.1	0.5

Suppose today the quality of air is dirty.

a) Modeling the scenario as a Markov model, determine the probability of clear air for the day after tomorrow. [4]

b) Determine the probabilities of each type of air in the long-run (stationary distribution). [4]

2. Suppose that a delivery robot must carry out a number of delivery activities, *a*, *b*, *c*, *d*, and *e*. Suppose that each activity happens at any of times *1*, *2*, *3*, or *4*. Let *A* be the variable representing the time that activity *a* will occur, and similarly for the other activities.

Suppose the following constraints must be satisfied:

Activity b cannot be done at time 3.

Activity c cannot be done at time 2.

Activity a and d must be done at the same time.

Activity a and b cannot be done at the same time.

Activity b and c cannot be done at the same time.

Activity b and d cannot be done at the same time.

Activity c must be done before activity d.

Activity e must be done before all other activities.

a) Formulate the problem as a CSP. Clearly mention the required variables, domains and constraints. [1+1+2]

b) Draw the constraint graph. [1]

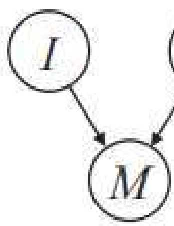
c) Show the steps followed by the backtracking algorithm with the minimum remaining values heuristic and the degree heuristic. [3]

3. There has been an outbreak of mumps at UIU. You feel fine, but you're worried that you might already be infected and therefore won't be healthy enough to take your CSI 341 Final exam. You decide to use Bayes nets to analyze the probability that you've contracted the mumps. You first think about the following two factors:
   - You think you have immunity from the mumps (+i) due to being vaccinated recently, but the vaccine is not completely effective, so you might not be immune (−i).
   - Your roommate didn't feel well yesterday, and though you aren't sure yet, you suspect they might have the mumps (+r).

   Denote these random variables by I and R. Let the random variable M take the value +m if you have the mumps, and −m if you do not. You write down the following Bayes net to describe your chances of being sick:

I	$P(I)$
$+i$	0.8
$-i$	0.2

R	$P(R)$
$+r$	0.4
$-r$	0.6

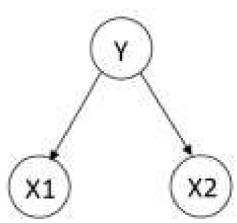


I	R	M	$P(M \mid I,R)$
$+i$	$+r$	$+m$	0
$+i$	$+r$	$-m$	1.0
$+i$	$-r$	$+m$	0
$+i$	$-r$	$-m$	1.0
$-i$	$+r$	$+m$	0.7
$-i$	$+r$	$-m$	0.3
$-i$	$-r$	$+m$	0.2
$-i$	$-r$	$-m$	0.8

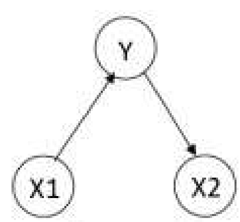
   a) Draw the joint distribution over I, M, and R, P(I, M, R). [3]
   b) What is the marginal probability P(+m) that you have the mumps? [2]
   c) Assuming you do have the mumps, you're concerned that your roommate may have the disease as well. What is the probability P(+r | + m) that your roommate has the mumps given that you have the mumps? Note that you still don't know whether or not you have immunity. [2]

4. Draw the Bayesian Network that corresponds to this conditional probability: [3]
   P(A | B,C,E) P(B | D,G) P(C | E,F,H) P(D | G) P(E| G,H) P(F | H) P(G | H) P(H)

5. Do Bayes Net A and Bayes Net B in the following figure represent different conditional independence relations? If so, please give a condition independence assumption that holds for one of these networks but not the other. If they represent the same conditional independence assumptions, then list the complete set of conditional independencies they represent. [2]



Bayes net A

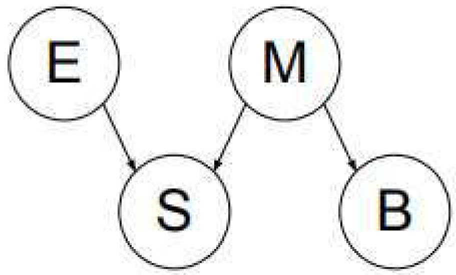


Bayes net B

6. Consider the following Bayes net.

$P(E)$	
$+e$	0.4
$-e$	0.6

$P(S \mid E, M)$			
$+e$	$+m$	$+s$	1.0
$+e$	$+m$	$-s$	0.0
$+e$	$-m$	$+s$	0.8
$+e$	$-m$	$-s$	0.2
$-e$	$+m$	$+s$	0.3
$-e$	$+m$	$-s$	0.7
$-e$	$-m$	$+s$	0.1
$-e$	$-m$	$-s$	0.9



$P(M)$	
$+m$	0.1
$-m$	0.9

$P(B \mid M)$		
$+m$	$+b$	1.0
$+m$	$-b$	0.0
$-m$	$+b$	0.1
$-m$	$-b$	0.9

Now find the following probabilities: [2+2+2=6]

a) P(−e, −s, −m, −b)
b) P(+m| + b)
c) P(+m| + s, +b, +e)

7. A tourism company offers special discount card to its customers. Last year, they called many customers and a fraction of the customers accepted the offer. Here is the data that was collected by the Manager:

Job Type	Income Level	Likes To Hangout	Offer Taken
Engineer	High	Yes	Yes
Doctor	High	Yes	No
Engineer	Medium	No	Yes
Teacher	Medium	No	Yes
Doctor	Medium	Yes	Yes
Engineer	Medium	No	No
Teacher	High	Yes	No
Doctor	High	Yes	No
Teacher	Medium	Yes	Yes
Doctor	Medium	No	No

(a) Determine whether a person will take the offer or not for the data <Engineer, Medium, Yes> using a Naive Bayes Classifier with Laplacian smoothing constant k=1. [5]

(b) Draw the Naive Bayesian network used to solve this problem. [1]