JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

Test 2 Examination-April-2025

B.Tech -VIII Semester (CSE/IT)

COURSE CODE (CREDITS): 19B1WCI832 (3)

MAX. MARKS: 25

COURSE NAME: Probabilistic Graphical Models

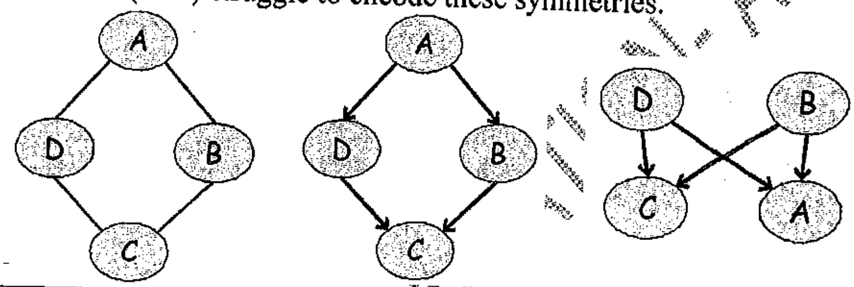
COURSE INSTRUCTORS: Vivek Kumar Sehgal,

MAX. TIME: 1.5Hr.

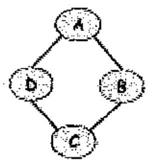
Note: (a) All questions are compulsory.

(b) All the parts of a question should be attempted together and in sequence.

Q.No	Question	CO	Marks
Q1	(a) The misconception example shown below describes two independencies: (A⊥C|B,D) and (B⊥D|A,C). Explain why Bayesian Networks (BNs) struggle to encode these symmetries.	CO-2	2



Q.No	Question	CO	Marks
Q1	(b) Using the factor graph below (factors $\phi_1(A,B), \phi_2(B,C), \phi_3(C,D), \phi_4(D,A)$), compute the partition function Z given the following assignments:	CO-2	3



$\phi_1[A,B]$

a^0	b^0	30
a^0	b^1	5
a^1	b^0	1
a^1	b^1	10

$\phi_2[B,C]$

b^0	c^0	100
b^0	c^1	1
b^1	c^0	1
b^1	c^1	100

$\phi_3[C,D]$

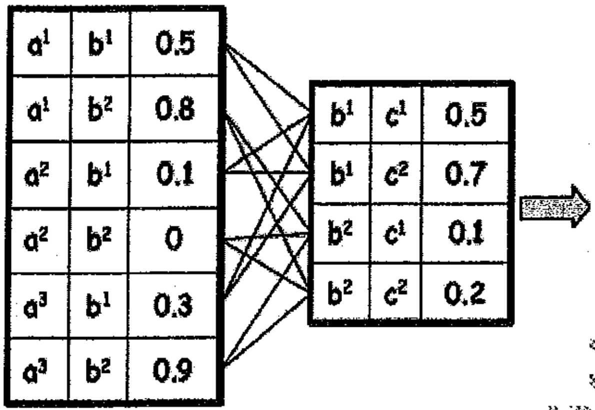
c^0	d^0	1
c^0	d^1	100
c^1	d^0	100
c^1	d^1	1

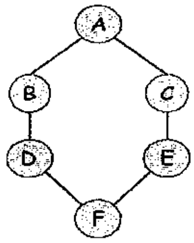
$\phi_4[D,A]$

d^0	a^0	100
d^0	a^1	1
d^1	a^0	1
d^1	a^1	100

Compute the joint assignment with unnormalized and normalized values.

Q.No	Question	CO	Marks
Q2	(a) Compare d-separation in Bayesian Networks and separation in Markov Networks. Use diagrams of a V structure (BN: $X \rightarrow Z \leftarrow Y$) and its corresponding Markov Network to explain why the latter fails to capture the marginal independence $(X \perp Y)$.	CO-2,3	2

<table>
<tr><td></td><td>(b) Given 3 disjoint set of variables $\mathbf{X}, \mathbf{Y}, \mathbf{Z}$, and factors $\phi_1(\mathbf{X}, \mathbf{Y}), \phi_2(\mathbf{Y}, \mathbf{Z})$, the factor product is defined as
$$\psi(\mathbf{X}, \mathbf{Y}, \mathbf{Z}) = \phi_1(\mathbf{X}, \mathbf{Y})\phi_2(\mathbf{Y}, \mathbf{Z})$$


Calculate $\psi(\mathbf{X}, \mathbf{Y}, \mathbf{Z})$ and conditions on $\mathbf{c}^1$</td><td></td><td>3</td></tr>
<tr><td rowspan="2">Q3</td><td>(a) Explain how energy functions relate to log-linear models in Markov networks. Use the energy values from table below to illustrate your answer. How does the energy function $\epsilon(C, D) = -4.61$ when $C \neq D$ affect the probability distribution?
<table>
<tr><td colspan="3">$\epsilon_1[A, B]$</td><td colspan="3">$\epsilon_2[B, C]$</td><td colspan="3">$\epsilon_3[C, D]$</td><td colspan="3">$\epsilon_4[D, A]$</td></tr>
<tr><td>a^0</td><td>b^0</td><td>−3.4</td><td>b^0</td><td>c^0</td><td>−4.61</td><td>c^0</td><td>d^0</td><td>0</td><td>d^0</td><td>a^0</td><td>−4.61</td></tr>
<tr><td>a^0</td><td>b^1</td><td>−1.61</td><td>b^0</td><td>c^1</td><td>0</td><td>c^0</td><td>d^1</td><td>−4.61</td><td>d^0</td><td>a^1</td><td>0</td></tr>
<tr><td>a^1</td><td>b^0</td><td>0</td><td>b^1</td><td>c^0</td><td>0</td><td>c^1</td><td>d^0</td><td>−4.61</td><td>d^1</td><td>a^0</td><td>0</td></tr>
<tr><td>a^1</td><td>b^1</td><td>−2.3</td><td>b^1</td><td>c^1</td><td>−4.61</td><td>c^1</td><td>d^1</td><td>0</td><td>d^1</td><td>a^1</td><td>−4.61</td></tr>
</table></td><td rowspan="2">CO-3</td><td>2</td></tr>
<tr><td>(b) Convert the following Markov Network to Bayesian Network using triangulation

</td><td>3</td></tr>
<tr><td>Q4</td><td>Prove that every undirected chordal graph $\mathcal{H}$ has a clique tree $\mathcal{T}$</td><td>CO-4</td><td>5</td></tr>
<tr><td>Q5</td><td>Let $\mathcal{H}$ be a chordal Markov network. Then prove that there is a BN $\mathcal{G}$ such that $\mathcal{I}(\mathcal{H}) = \mathcal{I}(\mathcal{G})$.</td><td>CO-4</td><td>5</td></tr>
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