NATIONAL UNIVERSITY OF SINGAPORE

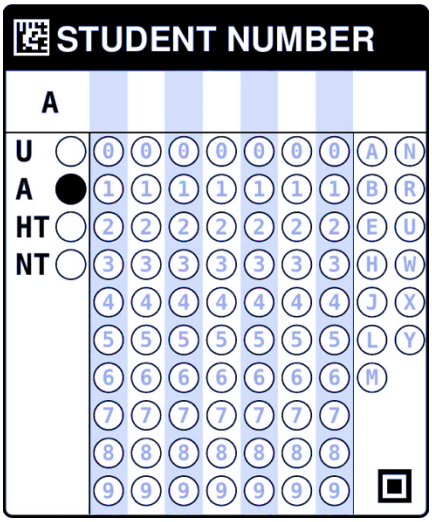
IT5005 – ARTIFICIAL INTELLIGENCE

(Semester II: AY2024/25)

Mid-Exam Answer Sheet

Time Allowed: 1 Hour

INSTRUCTIONS



1. Write your **Student Number** on the right AND, using pen or pencil, shade the corresponding circle **completely** in the grid for each digit or letter. DO NOT WRITE YOUR NAME!
2. Zero mark will be given if you write/shade your Student Number incompletely or incorrectly.
3. **Write your Student Number at the top of page 3**.
4. This answer sheet comprises **EIGHT (8) pages**.
5. All questions must be answered in the space provided; no extra sheets will be accepted as answers.
6. You must submit only this **ANSWER SHEET** and no other documents.
7. An excerpt of the question may be provided to aid you in answering in the correct box. It is not the exact question. You should still refer to the original question in the question paper.
8. You may write your answers using pencil (at least 2B) or pen as long as it is legible (no red ink, please).
9. The maximum mark for this paper is 50.
10. **Marks may be deducted** for (i) illegible handwriting, and/or (ii) excessively long explanations.
11. Each multiple choice question is intended to have only one answer. Shade the appropriate bubbles using pencil only.

For Examiner's Use Only		
Question	**Marks**	**Remarks**
Q1-5	/ 10	
Q6	/ 5	
Q7	/ 10	
Q8	/ 15	
Q9	/ 10	
Total	**/ 50**	

Part A: Multiple Choice Questions (Total: 10 marks)

Please shade only ONE bubble for each question. Please use ONLY pencil to shade.

	(A)	(B)	(C)	(D)	(E)
1.	○	○	●	○	○
2.	○	○	●	○	○
3.	○	○	●	○	○
4.	○	○	○	●	○
5.	○	○	●	○	○
	(A)	(B)	(C)	(D)	(E)

Part B (Total: 40 marks)

6. **Uninformed Search.** [5 marks]

For uniform costs, breadth-first search is optimal.

The state space is a tree, i.e., no redundant paths and cycles in the state space. Therefore, we don't need $reached$ data structure.

The delayed goal search is not efficient. We can do goal search as soon as we generate the node.

We can select $g(n)$ as the depth of the node, making uniform cost search a breadth-first search algorithm.

7. Informed Search [10 marks]

a. Admissibility and Consistency: [5 marks]

Write True/False in the table below and provide the rationale for False in the box below.

Heuristic	Admissible	Consistent
h_1	True	True
h_2	True	True
h_3	False	False
h_4	True	False
h_5	True	True

h_3 is not admissible because estimated cost of state A is larger than actual cost of reaching the goal state, i.e., $h_3(A) > C(A, G)$

h_3 is not consistent because the following condition are violated.

$$h_3(B) \leq C(B, C) + h_3(C)$$

$$h_3(C) \leq C(C, G) + h_3(G)$$

h_4 is not consistent because the following condition are violated.

$$h_4(A) \leq C(A, B) + h_3(B)$$

b. A* Search [2 marks]

C

c. Greedy Best First Search [2 marks]

C

d. Dominant Heuristics. [1 mark]

	A	B	C	D	G
Heuristic	4	2	1	3	0

Student Number: **A** | | | | | | | | |

8. Propositional Logic

a. Propositional Forms [4 marks]

R1: $a \Leftrightarrow \neg b$

R2: $b \Leftrightarrow \neg c$

R3: $c \Leftrightarrow (\neg a \wedge \neg b)$

R4: $(a \vee b \vee c) \wedge \neg(a \wedge b) \wedge \neg(a \wedge c) \wedge \neg(b \wedge c)$

b. Conjunctive Normal Forms [4 marks]

R1: $(\neg a \vee \neg b) \wedge (a \vee b)$

R2: $(\neg b \vee \neg c) \wedge (b \vee c)$

R3: $(\neg c \vee \neg a) \wedge (\neg c \vee \neg b) \wedge (a \vee b \vee c)$

R4: $(a \vee b \vee c) \wedge (\neg a \vee \neg b) \wedge (\neg a \vee \neg c) \wedge (\neg b \vee \neg c)$

c. Whether B is telling the truth or not? [7 marks]

R1a: $\neg a \vee \neg b$

R1b: $a \vee b$

R2a: $\neg b \vee \neg c$

R2b: $b \vee c$

R3a: $\neg c \vee \neg a$

R3b: $\neg c \vee \neg b$

R3c: $a \vee b \vee c$

R4a: $a \vee b \vee c$ (coincides with R3c)

R4b: $\neg a \vee \neg b$ (coincides with R1a)

R4c: $\neg a \vee \neg c$ (coincides with R3a)

R4d: $\neg b \vee \neg c$ (coincides with R3b)

R5: $\neg b$ (refutation)

R6: a (R1b, R5 resolution)

R7: $\neg c$ (R3a, R6, resolution)

R8: b (R2b, R7, resolution)

R9: Contradiction (R5, R8)

Therefore, B is telling the truth.

9. Bayesian Networks. [10 marks]

a. Missing Probabilities [5 mark]

$Weather$	$Traffic$	$Probability$
bad	$heavy$	0.1
$good$	$heavy$	0.2
bad	$light$	x
$good$	$light$	y

From the law of total probability: $0.1 + 0.2 + x + y = 1$

$$\Rightarrow x + y = 0.7$$

The problem can be reformulated as the task of finding x and y such that

$P(Traffic|Weather) = P(Traffic)$

$P(Traffic = heavy) = 0.3$

$P(Traffic = light) = 0.7$

$P(Weather = bad) = 0.1 + x$

$P(Weather = good) = 0.2 + y$

Given $Traffic$ and $Weather$ are independent. Therefore,

$P(Traffic = heavy|Weather = bad) = P(Traffic = heavy) = 0.3$

$$P(Traffic = heavy|Weather = bad) = \frac{P(Traffic = heavy, Weather = bad)}{P(Weather = bad)}$$

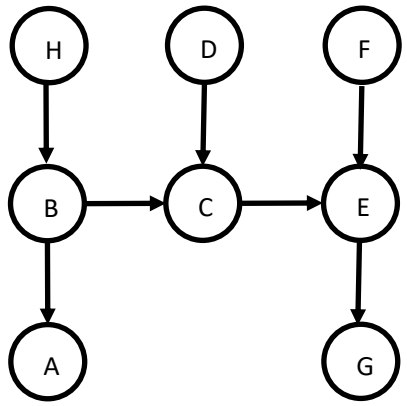
$$= \frac{0.1}{0.1 + x} = 0.3$$

Hence,

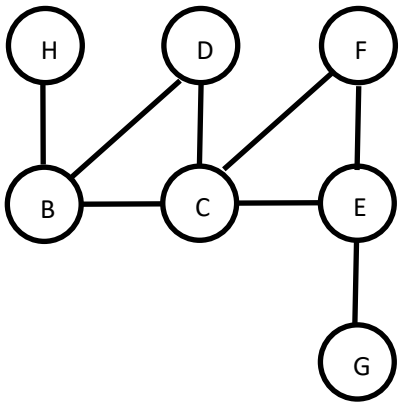
$x = 0.23$

$y = 0.47$

b(i). Prove/Disprove $H \perp F|G$ [2.5 marks]



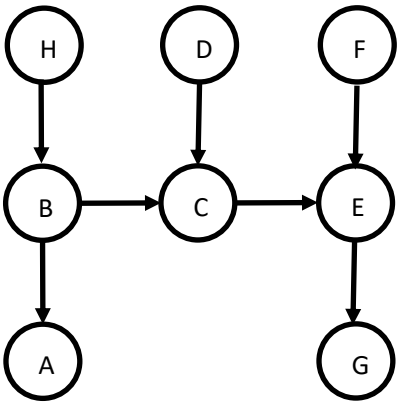
Undirected moralized ancestral subgraph

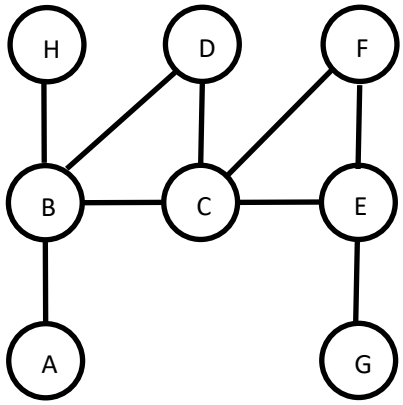


H and F are not guaranteed to be independent given G

b(ii). Prove/Disprove $A \perp D|G$ [2.5 marks]

Undirected moralized ancestral subgraph





A and D are not guaranteed to be independent given G

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