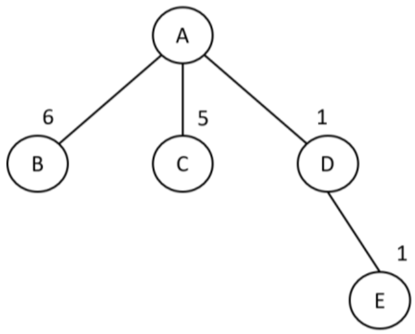
Solver: Rain Chua Qin Lei

1)

a)

i) F



Assuming B is the goal state, in this scenario, UCS will expand more nodes than BFS.

ii) T

iii) F

We will test if a state is goal state when we expand the state, **NOT** when we add it to the frontier. The professor emphasizes on this during lecture.

iv) T

v) T

b) <u>Variables</u>: The Cells

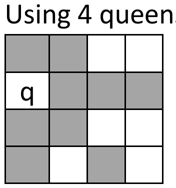
<u>Domains</u>: {mouse; empty; fruit; wall}

<u>Constraints</u>: Maze is of b x h squares
Coordinate of mouse cannot be the same as any of the wall.
The mouse can only move up, down, left, right (can only change its x or y coordinate)

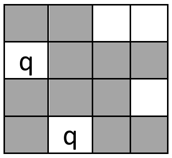
<u>Initial State</u>: {[x,y],m}
where [x,y] represent the coordinate of the mouse
m represents the number of fruits left

<u>Goal State</u>: {[x,y],0} where there is no fruit left.

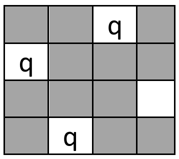
c) Constraint propagation is propagating the implications of a constraint on one variable onto other variables. This would reduce the number of nodes to be expanded as the constraint impose by one variable would eliminate the possibilities of certain values of another variable. Using 4 queens as an example.

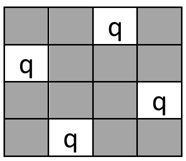


After placing the first queen, we can eliminate the possibilities of putting the second queen on the same row, column and diagonal of the first queen.



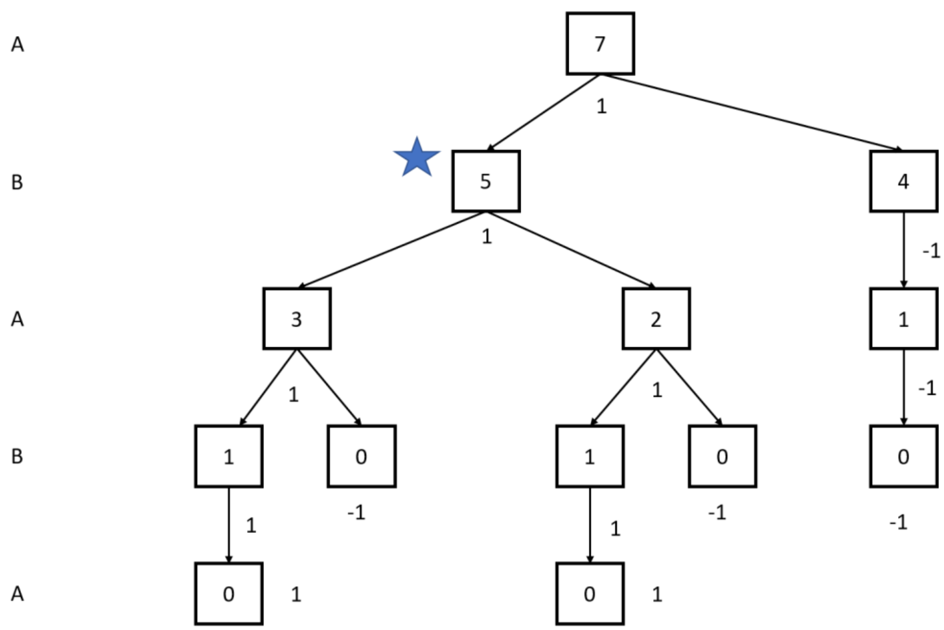
After placing the second queen, we apply the same constraint that no other queen can be placed on the same row, column and diagonal of the first 2 queens.





Applying constraint propagation reduce the search space as compared to testing if the constraints have been violated at every possible state.

d) The best initial move for player A is to remove 2 flags.



2)

a) The steps are sequential in the table.

<u>Breadth-First Search</u>

Node to be expanded	**Frontier**
	A
A	B, C, D
B	C, D

C	D, E, G
D	E, G
E	G, F
G	

1. Nodes will be expanded in this order: A → B → C → D → E → G
2. Final Path: A → C → G

b) Depth-First Search

Node to be expanded	**Frontier**
	A
A	B, C, D
B	C, D
C	E, G, D
E	F, G, D
F	G, D
G	

1. Nodes will be expanded in this order: A → B → C → E → F → G
2. Final Path: A → B → C → E → F → G

c) Uniform Cost Search

Node to be expanded	**Frontier [g(n)]**
	A (0)
A	D (1), B (3), C (6)
D	E (1+1), B (3), C (6)
E	B (3), F (2+2), C (6)
B	F (4), C (6)
F	C (6), G (4+5)
C	G (9)
G	

1. Nodes will be expanded in this order: A → D → E → B → F → C → G
2. Final Path: A → D → E → F → G

d) Greedy Search

Node to be expanded	**Frontier [h(n)]**
	A (5)
A	B (2), C (4), D (6)
B	C (4), D (6)
C	G (0), E (5), D (6)
G	

1. Nodes will be expanded in this order: A → B → C → G
2. Final Path: A → B → C → G (If parent can be updated), otherwise it is A → C → G

e) A* Search

Node to be expanded	**Frontier [g(n) + h(n) = f(n)]**
	A (0+5)
A	B (3+2), D (1+ 6), C (6+4)
B	D (7), C (10)
D	E (2+5), C (10)
E	F (4+4), C (10)
F	G (9), C (10)
G	

1. Nodes will be expanded in this order: A → B → D → E → F → G

2. Final Path: A → D → E → F → G

3)

a)

i) $\neg(A \wedge B) \Rightarrow C$

A	**B**	$\neg(\boldsymbol{A} \wedge \boldsymbol{B})$	**C**	$\neg(\boldsymbol{A} \wedge \boldsymbol{B}) \Rightarrow \boldsymbol{C}$
T	T	F	T	T
T	F	T	T	T
T	T	F	F	T
T	F	T	F	F
F	T	T	T	T
F	F	T	T	T
F	T	T	F	F
F	F	T	F	F

The sentence is satisfiable, but not valid.

ii) A⇒B⇒C

A	**B**	**A⇒B**	**C**	**A⇒B⇒C**
T	T	T	T	T
T	F	F	T	T
T	T	T	F	F
T	F	F	F	T
F	T	T	T	T
F	F	T	T	T
F	T	T	F	F
F	F	T	F	F

The sentence is satisfiable, but not valid.

b)

i) $(A \wedge B) \Rightarrow C \Leftrightarrow \neg A \vee B \Rightarrow C$

$LHS \quad \equiv (A \wedge B) \Rightarrow C$

$\equiv \neg(A \wedge B) \vee C$

$\equiv \neg\boldsymbol{A} \vee \neg\boldsymbol{B} \vee \boldsymbol{C}$

$RHS \quad \equiv \neg A \vee B \Rightarrow C$

$\equiv \neg(\neg A \vee B) \vee C$

$\equiv (\boldsymbol{A} \wedge \neg\boldsymbol{B}) \vee \boldsymbol{C}$

$RHS \neq LHS$, hence the logical equivalences do not hold.

ii) $A \Rightarrow B \Rightarrow C \Leftrightarrow (A \wedge \neg B) \vee C$
$A \Rightarrow B \Rightarrow C \Leftrightarrow \neg(\neg A \vee B) \vee C$
$\neg A \vee B \Rightarrow C \Leftrightarrow \neg(\neg A \vee B) \vee C$
$(\neg A \vee B) \Rightarrow C \Leftrightarrow (\neg A \vee B) \Rightarrow C$
The logical equivalences hold.

c)

i) Let Leo Messi in the room be LM,
Let Christiano Ronaldo in the room be CR,
Let TV is on be TV,
Let Aircon is on be A,
Let Light is on be L,
Let CCTV is on be C,
Let night time be N,
Let day time be D.
$D \Rightarrow CR$ ①
$N \Rightarrow LM$ ②
$\neg(LM \wedge CR)$ ③
$LM \vee CR \Leftrightarrow A \wedge TV$ ④
$LM \vee CR$ ⑤
$N \vee LM \Leftrightarrow CCTV \wedge L$ ⑥

ii) Prove that $CR \Rightarrow \neg CCTV \wedge \neg L$
Using refutation, let $\neg(\ CR \Rightarrow \neg(CCTV \wedge L))$ be true
$\neg\big(\ CR \Rightarrow \neg(CCTV \wedge L)\big) \equiv \neg\big(\neg\ CR \vee \neg(CCTV \wedge L)\big)$
$\equiv CR \wedge CCTV \wedge L$ ⑦
From ⑦, $\vDash CR$ ⑧
From ⑦, $\vDash CCTV$ ⑨
From ⑦, $\vDash L$ ⑩
From ③, $\vDash \neg LM \vee \neg CR$ ⑪
From ⑧, ⑪, $\vDash \neg LM$ ⑫
From ②, $\vDash \neg N \vee LM$ ⑬
From ⑫, ⑬, $\vDash \neg N$ ⑭
From ⑥, $\vDash (N \vee LM \Rightarrow CCTV \wedge L) \wedge (CCTV \wedge L \Rightarrow N \vee LM)$
$\equiv \big(\neg(N \vee LM) \vee (CCTV \wedge L)\big) \wedge \big(\neg(CCTV \wedge L) \vee (N \vee LM)\big)$
$\equiv \big((\neg N \wedge \neg LM) \vee (CCTV \wedge L)\big) \wedge \big((\neg CCTV \vee \neg L) \vee (N \vee LM)\big)$
$\vDash \neg CCTV \vee \neg L \vee N \vee LM$ ⑮
From ⑨, ⑮, $\vDash \neg L \vee N \vee LM$ ⑯
From ⑩, ⑯, $\vDash N \vee LM$ ⑰
From ⑭, ⑰, $\vDash LM$ ⑱
From ⑫, ⑱, $\vDash \emptyset$
Since there is a contradiction, then it is proven that CCTV and Light cannot be on if Ronaldo is in the room.

4)

a)

i) Not all students take AI.
ii) Not all students who take AI pass AI.
iii) All students who pass all hard subjects are diligent.
iv) AI is a hard subject.
v) Paul Pogba pass AI.

b)

i) $\exists x, \neg(Student(x) \Rightarrow Takes(x, AI))$
$\exists x, \neg(\neg Student(x) \vee Takes(x, AI))$
$\exists x, Student(x) \wedge Takes(x, AI)$
$Student(PaulPogba)$ -- (1)
$Takes(PaulPogba, AI)$ -- (2)

ii) $\exists x, \neg(Student(x) \wedge Takes(x, AI) \Rightarrow pass(x, AI))$
$\exists x, \neg\left(\neg(Student(x) \wedge Takes(x, AI)) \vee pass(x, AI)\right)$
$\exists x, \neg(\neg Student(x) \vee \neg Takes(x, AI) \vee pass(x, AI))$
$\exists x, Student(x) \wedge Takes(x, AI) \wedge \neg pass(x, AI)$
$Student(PaulPogba)$ -- (3)
$Takes(PaulPogba, AI)$ -- (4)
$Pass(PaulPogba, AI)$ -- (5)

iii) $\forall x, y, \neg(student(x) \wedge pass(x, y) \wedge subjectHard(y)) \vee diligent(x)$
$\forall x, y, \neg student(x) \vee \neg pass(x, y) \vee \neg subjectHard(y) \vee diligent(x)$
$\neg student(x) \vee \neg pass(x, y) \vee \neg subjectHard(y) \vee diligent(x)$ -- (6)

iv) $subjectHard(AI)$ -- (7)

v) $Pass(PaulPogba, AI)$ -- (8)

c) By refutation, prove diligent $\neg(PaulPogba)$ -- (9)
From (9) & (5), $\neg student(PaulPogba) \vee \neg pass(PaulPogba, y) \vee \neg subjectHard(y)$ -- (10)
$Subst\ \{x/PaulPogba\}$
From (10) & (7), $\neg student(PaulPogba) \vee \neg pass(PaulPogba, AI), Subst\{y/AI\}$ -- (11)
From (11) & (5), $\neg student(PaulPogba)$ -- (12)
From (12) & (3), $\vDash \emptyset$
This is a contradiction, hence Paul Pogba is diligent.

--End of Answers--