1)

a)

i) True
ii) True
iii) False
iv) True
v) False

b) States: 11 variables (10 places of interest and hotel) with 2 states each, visited (X) and not visited (O). 1 variable which keeps track of time taken so far with a value in minutes.
Initial State: (O, O, O, O, O, O, O, O, O, O, O, 0)
Goal Test: Sum of first 10 variables equal to 6 and 11th variable (hotel) is X.
Operators: Visit a place (O, O, O, O, O, O, O, O, O, O, O, 0) → (X, O, O, O, O, O, O, O, O, O, O, n) where n is the time taken
Path Cost: Variable for time taken

c) This is because the game GO has many grids available and it is a 2-player game. Meaning that each player has many possible moves and each players action will affect the next players decision. This causes the branching factor to become very high. If we used the tree search algorithms that we have studied in our course, we would have run out of memory computing the entire search tree. We would have also run out of time as there is a turn timer for each players action.

d) A(5), B(5), C(3), D(5), E(13), F(3), G(10)
Therefore, the most optimal move is to take B.

2)

a) Breadth-First Search

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

Expansion order: S, A, B, C, D, E, F, G
Final path order: S, B, E, G

b) Depth-First Search

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

B	**D, E,** C
D	**E, F**, C
E	**G**, F, C
G	

Expansion order: S, A, B, D, E, G [Frontier order can change; based on alphabetical order. Just ensure that it still follow the DFS rule.]
Final path order: S, A, B, D, E, G

c) Uniform Cost Search

Node to be expanded	**Frontier (g cost)**
	S (0)
S (0)	A (1), B (5)
A (1)	B (1+2=3), C (1+3=4), D (1+4=5),
B (3)	C (4), D (5), E (3+3=6)
C (4)	D (5), E (6), F (4+5=9)
D (5)	E (6), F (9)
E (6)	F (9), G (6+10=16)
F (9)	G (9+5=14)
G (14)	

Expansion order: S(0), A(1), B(3), C(4), D(5), E(6), F(9), G(14)
Final path order: S, A, C, F, G

d) Greedy Search

Node to be expanded	**Frontier (h cost)**
	S (9)
S (9)	B (6), A (8)
B (6)	D (4), E (6), A (8)
D (4)	F (3), E (6), A (8)
F (3)	G (0), E (6), A (8)
G (0)	

Expansion order: S(9), B(6), D(4), F(3), G(0)
Final path order: S, B, D, F, G

e) A* Search

Node to be expanded	**Frontier**
	S (9+0=9)
S (9)	A (8+1=9), B (6+5=11)
A (9)	B (6+3=9), D (4+5=9), C (7+4=11)
B (9)	D (9), C (11), E (6+6=12)
D (9)	C (11), E (12), F (3+11=14)
C (11)	E (12), F (3+9=12)
E (12)	F (12), G (0+16=16)
F (12)	G (0+14=14)
G (14)	

Expansion order: S(9), A(9), B(9), D(9), C(11), E(12), F(12), G(14)
Final path order: S, A, C, F, G

3)

a) A proposition is simply a statement. Propositional logic studies the ways statements can interact with each other. It is important to remember that propositional logic does not really care about the content of the statements. For example, in terms of propositional logic, the claims, "if the moon is made of cheese then basketballs are round," and "if spiders have eight legs then Sam walks with a limp" are the same.
First-order logic is symbolized reasoning in which each sentence, or statement, is broken down into a subject and a predicate. The predicate modifies or defines the properties of the subject. In first-order logic, a predicate can only refer to a single subject. First-order logic is also known as first-order predicate calculus or first-order functional calculus.
Fuzzy logic is a generalization of standard logic, in which a concept can possess a degree of truth anywhere between 0.0 and 1.0. Standard logic applies only to concepts that are completely true (having degree of truth 1) or false (having degree of truth 0). Fuzzy logic is supposed to be used for reasoning about inherently vague concepts.

b)

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

$$
\begin{aligned}
LHS \quad &\equiv A \Rightarrow B \Rightarrow C \\
&\equiv (\neg A \vee B) \Rightarrow C \\
&\equiv \neg(\neg A \vee B) \vee C \\
&\equiv \neg(A \Rightarrow B) \vee C \\
&\equiv RHS
\end{aligned}
$$

$\neg(A \wedge B) \Leftrightarrow A \Rightarrow \neg B$

$$
\begin{aligned}
LHS \quad &\equiv \neg(A \wedge B) \\
&\equiv \neg A \vee \neg B \\
&\equiv A \Rightarrow \neg B \\
&\equiv RHS
\end{aligned}
$$

ii)

A	**B**	**C**	**A⇒B**	**A⇒B⇒C**	**A⇒ ¬B**
1	1	1	1	1	0
1	1	0	1	0	0
1	0	1	0	1	1
1	0	0	0	1	1
0	1	1	1	1	1
0	1	0	1	0	1
0	0	1	1	1	1
0	0	0	1	0	1

Therefore, it is not equivalent.

iii) It is satisfiable but not valid.

c)

i) $JoseWorksHard \Rightarrow ManUWins \qquad (1)$
$ManUWins \Rightarrow FansHappy \qquad (2)$

$FansHappy \Rightarrow ManURich$ (3)
$JoseWorksHard$ (4)
From (4) and (1), $\vDash ManUWins$ (5)
From (5) and (2), $\vDash FansHappy$ (6)
From (6) and (3), $\vDash \boldsymbol{ManURich}$

ii) Refer to (1) – (4) in part i.
Prove by refutation, assume that $\neg ManURich$ (5)
From (3), $\vDash \neg FansHappy \vee ManURich$ (6)
From (5) and (6), $\vDash \neg FansHappy$ (7)
From (2), $\vDash \neg ManUWins \vee FansHappy$ (8)
From (7) and (8), $\vDash \neg MansUWins$ (9)
From (1), $\vDash \neg JoseWorksHard \vee ManUWins$ (10)
From (9) and (10), $\vDash \neg JoseWorksHard$ (11)
From (4) and (11), $\vDash \emptyset$
Since there is a contradiction, Manchester United is rich.

4)

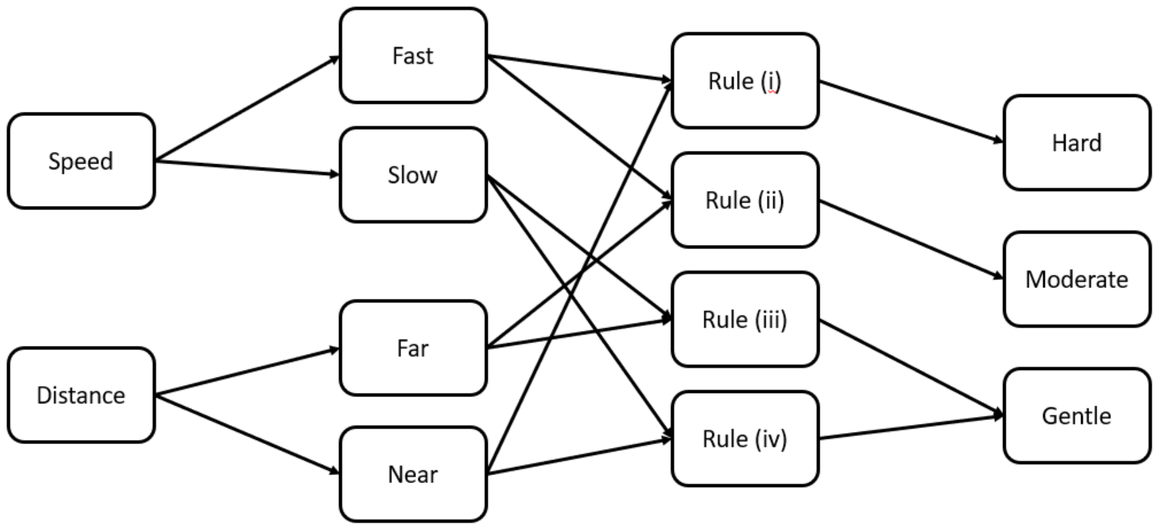
a)

i) All teachers teach their students.
ii) If a student works hard, is smart and gets taught, he will pass.
iii) If a student passes, the teacher is happy.
iv) PaulPogba works hard.
v) PaulPogba is smart.
vi) JoseMourinho is a teacher.
vii) PaulPogba is a student of JoseMourinho.

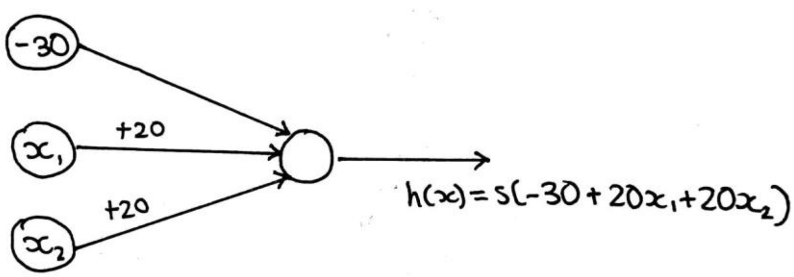
b) $\neg(Teacher(x) \wedge Student(y, x)) \vee Teach(x, y)$ ①
$\neg\left(Workhard(y) \wedge Smart(y) \wedge Teach(x, y)\right) \vee Pass(y)$ ②
$\neg Pass(y) \vee Happy(x)$ ③
$Workhard(PaulPogba)$ ④
$Smart(PaulPogba)$ ⑤
$Teacher(JoseMourinho)$ ⑥
$Student(PaulPogba, JoseMourinho)$ ⑦
For proof by refutation, let $\neg Happy(JoseMourinho)$ be true ⑧
From ③,⑧, $SUBST\ \theta = \{\frac{x}{JoseMourinho}, \frac{y}{PaulPogba}\} \vDash \neg Pass(PaulPogba)$ ⑨
From ②, $\neg Workhard(y) \vee \neg Smart(y) \vee \neg Teach(x, y) \vee Pass(y)$ ⑩
From ⑨,⑩, $SUBST\ \theta = \{\frac{x}{JoseMourinho}, \frac{y}{PaulPogba}\} \vDash \neg Workhard(PaulPogba) \vee$
$\neg Smart(PaulPogba) \vee \neg Teach(JoseMourinho, PaulPogba)$ ⑪
From ④,⑪, $\vDash \neg Smart(PaulPogba) \vee \neg Teach(JoseMourinho, PaulPogba)$ ⑫
From ⑤, ⑫, $\vDash \neg Teach(JoseMourinho, PaulPogba)$ ⑬
From ①, $\vDash \neg Teacher(x) \vee \neg Student(y, x) \vee Teach(x, y)$ ⑭
From ⑬, ⑭, $SUBST\ \theta = \{\frac{x}{JoseMourinho}, \frac{y}{PaulPogba}\} \vDash \neg Teacher(JoseMourinho) \vee$
$\neg Student(PaulPogba, JoseMourinho)$ ⑮

From ⑥,⑮, $\vDash Student(PaulPogba, JoseMourinho)$ ⑯
From ⑦, ⑯, $\vDash \emptyset$
Since there is a contradiction, it is true that Jose Mourinho is happy.

c)



d)



X_1	X_2	h(x)
0	0	s (-30) ≈ 0
0	1	s (-10) ≈ 0
1	0	s (-10) ≈ 0
1	1	s (10) ≈ 1

--End of Answers--