Problem 1 Answer the following questions with True or False. (30 points, 2 points for each question)

1. An agent that senses only partial information about the state cannot be perfectly rational.

2. Every agent is rational in an unobservable environment.

3. "Strikking av en sokk involves a fully observable, deterministic, sequential, static, continuous, single agent environment.

4. "Bidding in auction" involves a fully observable, strategic, sequential, static, discrete, multi-agent.

5. The Turing test evaluates a computer system's ability to act rationally.

6. A stochastic environment is one in which the next state is completely determined by the agent's action.

7. An advantage of Hill Climbing search is that it requires minimal memory.

8. A danger of depth-first search is that it may not terminate if the search space is infinite, even if a finite solution exists.

9. The knowledge, i.e, the content of the knowledge base determines the system's performance while representation of knowledge determines its competence.

10. Principal of rationality (due to Allen Newell) maintains that the agent chooses actions in order to achieve its goal using the knowledge it has and the knowledge it might gather.

11. This is procedural knowledge about two cities in Norway: bigger (Oslo, Trondheim)

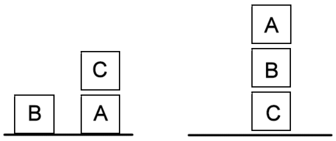
12. An advantage of declarative knowledge is the storage economy, in the sense that representation of declarative knowledge needs less memory than procedural knowledge.

13. The production rules in a Rule-based system is represented in the " working memory".

14. Assume a rule-based system for classification of fruits. Assume also that the system is currently at time t2 and it is using a "*refractory*" conflict resolution strategy. The system will fire the rule R5 at t2.

Step	Applicable Rules	Chosen Rule	Derived Facts
t1	R2, R5	R2	
t2	R2, R5	R5	

15. Consider a block world problem where the goal is On(A,B), On(B,C), and the precondition is On(C,A), On(B,Table), On(A,Table), Clear(C), Clear(B), Block(A), Block(B), Block(C). See the figure below showing the initial and the goal states:



Suppose a planner that, given subgoals $G_1,...,G_n$, solves each subgoal consecutively (i.e., first one goal, and then the next one,…) in a certain order. If we use such a planner to solve the planning problem above and solve the goals in the given order (i.e., On(A,B), On(B,C)) the planning will obtain an optimal plan.

Problem 2 Translate the following sentences in English to sentences in first order predicate logic (20 points, 2 points for each question)

1. All the existing kinds of birds can fly
2. Some existing kinds of birds can fly
3. At least two existing kinds of birds can fly
4. All existing kinds of birds can fly, except two.
5. All birds that are not penguins fly
6. There are no green Martians.
7. Everything painted by Picasso is valuable.
8. Not all people have a cell phone.
9. Everyone who owns a violin knows someone that likes music written by Mozart.
10. Every student at NTNU knows someone who likes dogs.

Problem 3 (15 points, 10 for part 1 and 5 pts for part2)

Part 1: Figure 1 displays the use of model checking to test whether the following is a **valid** logical expression (using the formal definition of logical validity):

$$\{(A \Rightarrow B) \Rightarrow C\} \Rightarrow \{(C \land A) \Rightarrow B\}$$

A	B	C	$A \Rightarrow B$	$(A \Rightarrow B) \Rightarrow C$	$(C \land A)$	$(C \land A) \Rightarrow B$
0	0	0	1	0	0	1
0	0	1	1	1	0	1
0	1	0			0	
0	1	1			0	
1	0	0	0	1	0	
1	0	1	0	1	1	
1	1	0	1		0	1
1	1	1	1		1	1

Figure 1

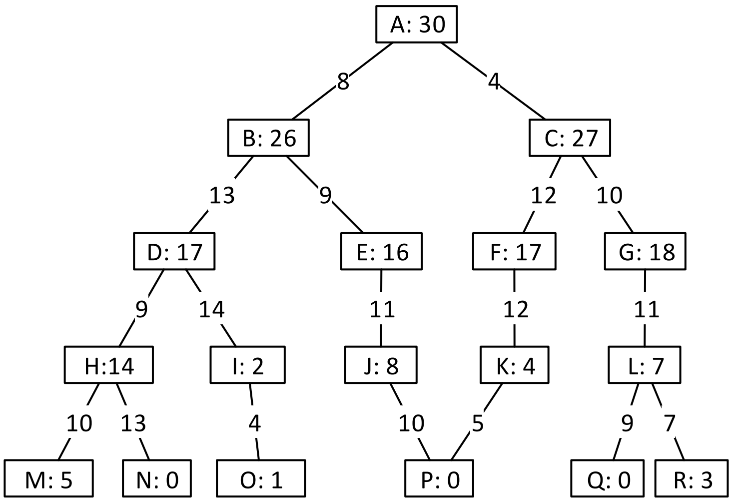
Fill in all missing cells of the table with a 1 (True) or 0 (False). Next, based on the completed table, tell whether or not the expression is valid.

Part 2: Answer the following questions with True or False (5 points, 1 points each question)

1. It is possible to remove the following two primitives from FOPL and still be able to represent all of the same expressions as in standard FOPL: OR and FORALL.
2. In a formal logic, the following expression is false: All 3-headed unicorns in Norway have purple tails.
3. Resolution is an effective (though not necessarily optimal) method for converting logical expressions into horn clauses.
4. It is always easier to solve logic problems using backward chaining than forward chaining.
5. One of the main benefits of FOPL compared to the vast majority of programming languages is the clean separation between the knowledge and the inference machinery.

Problem 4 (20 points)

A search graph is shown below. Node A is the initial state and the nodes N, P, and Q are goal states. Each node is labeled with a number corresponding to the value of the heuristic evaluation function for that node, e.g. [A: 30] node with label A has heuristic function value 30.

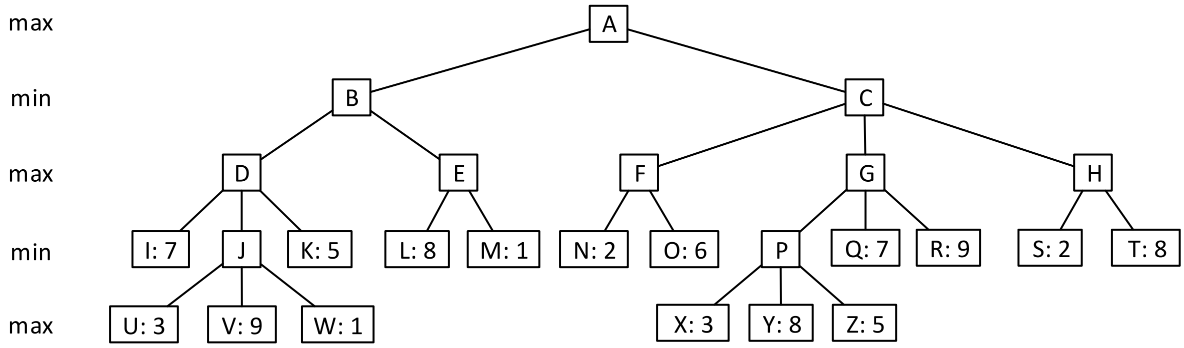


Answer the following questions:

1. Assuming greedy best-first search strategy, list the nodes in the order that they get expanded. (2 points)
2. Assuming greedy best-first search strategy, list the nodes along the final path between the initial state and the goal state. (2 points)
3. Assuming A* search strategy, list the nodes in the order that they get expanded. (8 points)
4. Assuming A* search strategy, list the nodes along the final path between the initial state and the goal state. (2 points)
5. Find a node for which heuristic value is not admissible. Explain why it is not admissible.(3 points)
6. Find a node for which heuristic value is admissible but not consistent. Explain why it is not consistent. (3 points)

Problem 5 (15 points)

1. What kind of games the minimax algorithm is used for? (2 points)
2. Given that the maximum depth of a game tree is *m* with *n* legal moves at each point, what is the time complexity of the minimax algorithm? (2 points)
3. Why we may want to use alpha-beta pruning? (2 points)
4. Assume the game tree below in which the evaluation function values are given for the leaf nodes. Assuming an alpha-beta search strategy left to right, which nodes will not be expanded? (9 points)


max
min
max
min
max
A
B
C
D
E
F
G
H
I: 7
J
K: 5
L: 8
M: 1
N: 2
O: 6
P
Q: 7
R: 9
S: 2
T: 8
U: 3
V: 9
W: 1
X: 3
Y: 8
Z: 5

GOOD LUCK!