End-Semester Examination December 2020

CSL 412- ARTIFICIAL INTELLIGENCE (SLOT D)

Time: 1 Hr 30 Min **Max. Marks: 35**

Instruction to the candidates

Use suitable assumptions wherever necessary and state them in the answer script.

Q1. Translate each of the following sentences into sentences in first-order logic. State the intended interpretation for any predicate, function or constant that you use.

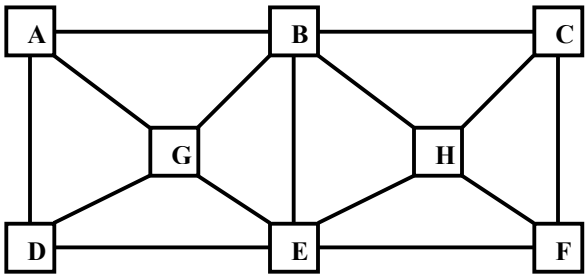
i. All PCs are computers.
ii. If someone owns a PC then there is some computer that he/she owns.
iii. XYZ owns a PC.
iv. Anyone who owns a computer is a dweeb. (Write this as a first-order Horn clause)

a. Does the statement **i** above logically entail the statement **ii**? Does **ii** logically entail **i**?
b. Apply existential elimination to **iii**.
c. Consider that the knowledge base contains the sentences **i**, **iv**, and b (above). Draw the proof tree using backward chaining which solves the query "Who is a dweeb?" Mention the unifiers in the proof tree. (7)

Q2. Consider the problem of colouring the following graph using three colours 1, 2, and 3. The problem is modeled as a constraint satisfaction problem such that no two adjacent vertices have the same colour.

Show that by applying the minimum remaining values, the least constraining value, and the degree heuristics simultaneously, we can have a possible colour assignment for the vertices. Give the complete execution steps after each possible variable assignment.

Simultaneously apply the techniques of forward checking and constraint propagation to show that it is possible to detect the inconsistency of the partial assignment A = 1; C = 2, thereby effecting an early backtrack. (7)



Q3. (a) Which of the following are correct translations of "No two adjacent countries have the same color"?
(¥ refers to the 'for all' universal quantifier)

i. ¥x, y ¬Country(x) V ¬Country(y) V ¬Adjacent(x, y) V ¬(Color(x) = Color(y)).
ii. ¥x, y (Country(x) Λ Country(y) Λ Adjacent(x, y) Λ ¬(x = y)) → ¬(Color(x) = Color(y)).
iii. ¥x, y Country(x) Λ Country(y) Λ Adjacent(x, y) Λ ¬(Color(x) = Color(y)).
iv. ¥x, y (Country(x) Λ Country(y) Λ Adjacent(x, y)) → ¬Color(x = y).

(2)

(b) Represent the following sentences in First Order Logic (FOL) and convert it into the Conjunctive Normal Form (CNF).

Everyone who loves all animals is loved by someone.

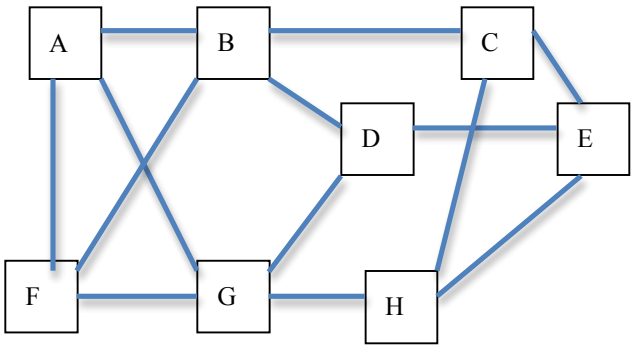
Give an intuitive reason for the introduction of Skolem functions in this example. (4)

Q4. Consider the Wumpus world example discussed in the class. Assume that there is only one wumpus in a 4 * 4 grid and that the agent is equipped with one arrow which can kill the wumpus if the agent shoots in the cell where the wumpus is present. Assume that the agent starts in cell [1, 1] and moves right and finds breeze in [1, 2]. It comes back and moves up and finds stench in [2, 1].

With this, the agent should be able to conclude that there is pit in [1, 3] and the wumpus is in [3, 1].

Encode the wumpus world using sentences in propositional logic and then convert the sentences into the conjunctive normal form (CNF). Using resolution, show the proof trees for each of the above conclusions. (6)

Q5. Trace the operation of Uniform Cost search, Iterative Deepening Search, A* and Recursive Best First search techniques applied to the problem of getting to node E from node A using the straight-line distance heuristic applied to the following graph. The lengths of the edges (L) and the straight line distances (SLD) to E are given below. Find out the total number of nodes expanded by each of these algorithms (don't forget to count the repeated generation of the same nodes). At the maximum, how many of nodes need to be stored in memory by each of the above search techniques? (9)



L(A,B) = 3
L(A,F) = 2
L(A,G) = 6
L(B,C)=4
L(B,D)=5
L(B,F)=5
L(F,G)=3
L(G,D)=4
L(G,H)=2
L(C,E)=5
L(C,H)=2
L(D,E)=4
L(E,H)=4

SLD(A,E)=8
SLD(B,E)=6
SLD(C,E)=4
SLD(D,E)=3
SLD(E,E)=0
SLD(F,E)=6
SLD(G,E)=4
SLD(H,E)=2