General instructions.
• This is an individual assignment. You can discuss solutions with your classmates, but should only exchange information orally, or else if in writing through the discussion board on myCourses. All other forms of written exchange are prohibited.
• Unless otherwise mentioned, the only sources you should need to answer these questions are your course notes, the textbook, and the links provided. Any other source used should be acknowledged with proper referencing style in your submitted solution.
• Submit a single pdf document containing all your pages of your written solution on your McGill’s myCourses account. You can scan-in hand-written pages. If necessary, learn how to combine many pdf files into one.

Question 1: Searching under uncertainty
Consider the simple maze problem shown in this figure. The agent starts at S and much reach G but knows nothing of the environment. It does not know where the walls are, nor where it starts. It knows there are 9 states in the environment and that the actions Up, Down, Left, Right have their usual (deterministic) effects unless blocked by a wall, in which case the agent stays in place. When in a given state, the agent can perceive the pattern of nearby walls (e.g. $s_4 = \Box$).
Assume the agent’s initial belief includes all states, except G.
   a) What is the total number of possible beliefs in this domain?
   b) How many distinct percepts are possible in this domain?
   c) Draw the belief tree from the initial belief to two actions ahead.
   d) Given a conformant plan to reach the goal from the given initial belief.

Question 2: Propositional Logic
Consider a vocabulary with only four propositions, A, B, C, and D.
   a) How many models are there for the following sentences?
      i. $A \lor B$
      ii. $\neg B \lor \neg C \lor \neg D$
      iii. $(B \Rightarrow D) \land A \land B \land C \land \neg D$
   b) Say whether each of the following sentences is Valid, Unsatisfiable, or Satisfiable. Support your answer using truth tables or logical inference.
      i. False $|=\$ True.
      ii. True $|=\$ False.
      iii. $A =\Rightarrow A$
      iv. $A =\Rightarrow \neg A$
      v. $A \Leftrightarrow B$
      vi. $A \lor B \lor \neg B$
      vii. $((A \land B)\Rightarrow C) \Leftrightarrow ((A\Rightarrow C)\lor (B\Rightarrow C))$
      viii. $(A\Rightarrow B) =\Rightarrow (A\land C)\Rightarrow B$
      ix. $(A \lor B) \Rightarrow (A\lor B)$
**Question 3: First-order logic**

Consider the following facts:

Albert, Barbara and Clark belong to the Mountain Club. Every member of the Mountain Club is either a skier or a hiker or both. No hiker likes rain. All skiers like snow. Clark dislikes whatever Albert likes and likes whatever Albert dislikes. Albert likes rain and snow.

Assume you are limited to using the following predicates:

- Skier(x) : x is a skier
- Hiker(x) : x is a hiker
- Likes(x,y) : x likes y, where the domain of x is Mountain Club members and the domain of y is \{snow, rain\}.

a) Translate the facts listed above in first-order logic using the given predicates. Clearly distinguish between variables and constants in each formula.

b) Convert all the facts from part (a) to CNF form. Number each clause.

c) Using proof by resolution, answer the following query (or explain why it cannot be proven). For each step of a proof, clearly list what clause number (from part (b)) and what logic rule (from class slides) you are using.

Query: Is there a member of the Mountain Club that is a hiker but not a skier?


A finite Turing machine has a finite one-dimensional tape of cells, each cell containing one of a finite number of symbols. One cell has a read and write head above it. There is a finite set of states the machine can be in, one of which is the accept state. At each time step, depending on the symbol on the cell under the head and the machine’s current state, there are a set of actions we can choose from. Each action involves writing a symbol to the cell under the head, transitioning the machine to a state, and optionally moving the head left or right. The mapping that determines which actions are allowed is the Turing machine’s program. Your goal is to control the machine into the accept state.

Represent the Turing machine acceptance problem as a planning problem. If you can do this, it demonstrates whether a planning problem has a solution is at least as hard as the Turing acceptance problem, which is PSPACE-hard.

**Question 5: Complementary reading**

In this last question you will read a research paper, and answer questions related to it. The goal of the assignment is to deepen your understanding of planning algorithms. It is also intended to give you a chance to practice the skills required when reading advanced technical material, including the ability to extract key concepts, summarize, and objectively criticize the ideas presented.

Before proceeding further, read these instructions on "How to Read and Evaluate Technical Papers":


Now you are ready to start the assignment. Read the following paper:


http://ldc.usb.ve/~hector/reports/hsp-aij.ps

Finally, answer the following questions:

a) What are the motivations for this work? What problem are the authors trying to solve?

b) What are the proposed solutions? Describe the key technical ideas.

c) How are the proposed solutions evaluated? Describe the evaluation procedure and summarize the key results.

d) What are the pros and cons of the proposed solutions, compared to the other planning algorithms discussed in class?

e) What are future directions for this research?

f) What are the weaknesses of this paper? (e.g. Limitations in the proposed solutions, evaluation, writing, etc.)