HÁSKÓLINN Í REYKJAVÍK REYKJAVIK UNIVERSITY	T-622-ARTI, Introduction to Artificial Intelligence Spring 2011 **Problem Set 2** Worth 5% of final course grade Due by 23:59 on Thursday the 17th of March Group Size 1-2

Student Name: ____

1. (30%) Inference with Propositional Logic

You are an unmanned space ship sent to explore one of Jupiter's moons, Europa. Your precious **Knowledge Base** contains the following **sentences**:

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[A] ChemoSynth ⇒ LifeEnergy
[B] ¬ HighTemp ∧ TidalFlexing ⇒ Radiation
[C] Oxygen ∧ ¬ HydroThermal ⇒ LifeSafe
[D] HighTemp ∨ ¬ TidalFlexing ⇒ ¬ LifeSafe
[E] HydroThermal ∧ LifeEnergy ⇒ Life
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Once you arrive on Europa your sensors tell you the following:

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[F] ¬ Radiation
[G] Oxygen
[H] ChemoSynth
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Use inference to determine whether there is life on Europa or not. You may use the rules and equivalences shown on the formula page (at the back). Each time you add a new sentence to your Knowledge Base, indicate what sentences, equivalences and/or rules you are using (*note:* number of lines below does not indicate length of solution).

```
[I] ________________________________ from ____________

[J] ________________________________ from ____________

[K] ________________________________ from ____________

[L] ________________________________ from ____________

[M] ________________________________ from ____________

[N] ________________________________ from ____________
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[O] ______________________________ from ___________

[P] ______________________________ from ___________

[Q] ______________________________ from ___________

[R] ______________________________ from ___________

[S] ______________________________ from ___________

2. (20%) First Order Logic

Using at least the symbols Contains(x,y) and Good(x) write the **first order logic** statements that express the following:

a) Some good food contains chili powder.

b) All good food contains salt but no eggplant.

c) The food must be old or contain some eggplant if it is bad.

3. (30%) Knowledge Representation and Reasoning (with PowerLoom)

a) Translate the following sentences (using relation predicates, functions and constants) into First Order Logic statements for **PowerLoom**:

   a. Tony, Mike and John are members of the Alpine Club.
   HINT: you can suppose that being a "member" means being a "member of the Alpine Club";
   b. Every member of the Alpine Club who is not a Skier is a mountain Climber;
   c. Mountain climbers do not like rain, and anyone who does not like snow is not a skier;
   d. Mike dislikes whatever Tony likes, and likes whatever Tony dislikes;
   e. Tony likes rain and snow.

b) Is there a member of Alpine Club who is a mountain climber but not a skier? If so, who is?
HINT: use the retrieve command in PowerLoom to obtain this information from the Knowledge Base built so far.

c) **Submit your PowerLoom module file (*.PLM) as part of this problem set** (you can zip the files together if you want).

4. (20%) Planning

You are a **robot** that gets the task of securing the rooms of a building. The building has 3 rooms numbered 1 through 3. In order to secure a room you need to have the remote control that seals it shut. This remote control is currently sitting in one of the rooms. You have the following **STRIPS** operators available to you and the closed world assumption holds.

Action(GotoRoom(x,y)),
- **Precond:** At(robot, x)
- **Add**: At(robot, y)
- **Delete**: At(robot, x)

Action (PickUp(o)),
- **Precond**: At(robot,x) $\wedge$ At(o,x)
- **Add**: Holding(robot,o)
- **Delete**: At(o,x)

Action (Drop(o)),
- **Precond**: At(robot,x) $\wedge$ Holding(robot,o)
- **Add**: At(o,x)
- **Delete**: Holding(robot,o)

Action (SecureRoom(x)),
- **Precond**: At(robot,x) $\wedge$ Holding(robot,remote)
- **Add**: Secure(x)
- **Delete**: -

Initial State:
At(robot,3) $\wedge$ At(remote,2)

Goal State:
At(robot,1) $\wedge$ At(remote,1) $\wedge$ Secure(1) $\wedge$ Secure(2) $\wedge$ Secure(3)

You have decided to do backward chaining to plan your course of action. **Regress the goal** through **three actions**. Show both the actions and intermediate states.

Formula Page

Logical Equivalence:

1. $(a \wedge b) \equiv (b \wedge a)$
2. $(a \vee b) \equiv (b \vee a)$
3. $((a \wedge b) \wedge c) \equiv (a \wedge (b \wedge c))$
4. $((a \vee b) \vee c) \equiv (a \vee (b \vee c))$
5. $\neg (\neg a) \equiv a$
6. $(a \Rightarrow b) \equiv (\neg b \Rightarrow \neg a)$
7. $(a \Rightarrow b) \equiv (\neg a \vee b)$
8. $(a \Leftrightarrow b) \equiv ((a \Rightarrow b) \wedge (b \Rightarrow a))$
9. $\neg (a \wedge b) \equiv (\neg a \vee \neg b)$
10. $\neg (a \vee b) \equiv (\neg a \wedge \neg b)$
11. $(a \wedge (b \vee c)) \equiv ((a \wedge b) \vee (a \wedge c))$
12. $(a \vee (b \wedge c)) \equiv ((a \vee b) \wedge (a \vee c))$

Sound Inference Rules:

13. From { $(a \Rightarrow b)$, a} infer b (Modus Ponens)
14. From { $(a \Rightarrow b)$, $\neg b$} infer $\neg a$ (Modus Tolens)
15. From { a, b } infer $(a \wedge b)$
16. From { $(a \wedge b)$, . } infer a
17. From { $(a \wedge b)$, . } infer b