IITJ, B.Tech 3rd year(CSE), II Semester
First Mid-Sem. Examination-2016
CS323: Artificial Intelligence
(With solutions)

Duration: 1 Hour Max. Marks 35

Instructions:

- All questions are compulsory.
- All questions are in detail and complete in every respect.

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1. Show that in propositional logic, the modus tolens is sound, and abduction is not sound. [5]

   Ans. The modus tollens, i.e. $[(P \to Q) \wedge \neg Q] \to \neg P$ is tautology (i.e. valid), while the abduction, i.e., $[(P \to Q) \wedge Q] \to P$ is not tautology(i.e. not valid).

2. Use resolution to show that the following set of clauses is unsatisfiable. [5]

   $$\{p(a, z), \neg p(f(f(a)), a), \neg p(x, g(y)) \vee p(f(x), y)\}.$$

   Solution: Unifying $p(a, z)$ and $\neg p(x, g(y)) \vee p(f(x), y)$ with unifier $\{a/x, z/g(y)\}$, we get resolvent as $p(f(a), y)$. Next, it is not possible to unify $p(f(a), y)$ and $\neg p(f(f(a))$, hence unsatisfiable.

3. Let S and T be unification problems, in the form of conjunctive normal forms. Also, let σ be a most general unifier for S and θ be a most general unifier for $T\sigma$. Show that $\theta\sigma$ is a most general unifier for $S \cup T$. [5]

   Ans: The S and T are each CNFs. When σ is substituted, $S\sigma$ will be single clause after unification is performed by σ.
   Similarly, $T\sigma\theta$ is single clause, as unification will be performed by substitution of θ.

   Thus, we need to find results through:$S\sigma \cup T\sigma\theta$. So if we have θ substitution over this,

   $(S\sigma \cup T\sigma\theta)\theta$
   $\Rightarrow S\sigma\theta \cup T\sigma\theta\theta$
   $\Rightarrow S\sigma\theta \cup T\sigma\theta$
   $\Rightarrow (S \cup T)\sigma\theta$

   So, $\sigma\theta$ is mgu for $S \cup T$

4. Find out the disagreement sets and most general unifiers for following, if exists. The symbol "|" stands for concatenation of lists. [2.5, 2.5]

   (a) $nth(s(s(0)), [a, b, c], E)$ and $nth(s(N), [X|Xs], Y)$
   Ans: $\{N/s(0), X/a, Xs/[b, c], Y/E\}$

   (b) $f(y, g(A, A))$ and $f(Z, g(X, b(X)))$
   Ans: fails

5. Given a knowledge-base for an animal kingdom, infer *animal(bruno)* after adding *dog(bruno)*, in each of the following cases. Also, find out the total number of rules fired in each case.

   (a) backward chaining [5]

   (b) forward chaining [5]

S. No.	Rule
1	$sponge(x) \rightarrow animal(x)$
2	$arthopod(x) \rightarrow animal(x)$
3	$vertebrate(x) \rightarrow animal(x)$
4	$fish(x) \rightarrow vertebrate(x)$
5	$mammal(x) \rightarrow vertebrate(x)$
6	$carnivore(x) \rightarrow mammal(x)$
7	$dog(x) \rightarrow carnivore(x)$
8	$cat(x) \rightarrow carnivore(x)$

Solution. It is required to show that, $KB + dog(bruno) \rightarrow animal(bruno)$.
Forward Chaining. We start with rule 7, and unify $dog(bruno)$ with $dog(x)$. Next, we will successively infer and add *carnivore(bruno)*, *mammal(bruno)*, *vertebrate(bruno)*, and *animal(bruno)*. The query will then succeed immediately. The total work is proportional to the height of the hierarchy of this taxonomy, which is 4.

Backward-chaining. Alternatively, if we use backward chaining, the query $animal(bruno)$ will unify with the first rule above and generate the sub-query *sponge* $(bruno)$, which will initiate a search for *bruno* through all the subdivisions of sponges. Not finding, it tries with 2nd rule, but orthopod is not in consequent. Next, with rule 3, the goal driven chain is: "animal $\rightarrow$ vertebrate $\rightarrow$ fish", which fails. The successful invocation rule sequence is "$3 \rightarrow 5 \rightarrow 6 \rightarrow 7$." Thus, it searches the entire taxonomy of animals looking for $dog(bruno)$. We note that work done in the background chaining much more than forward chaining. But, this is not necessarily true always. □

6. The machine can be made intelligent by adding the features of *perceiving, analysis* and *act*. To make it more like, human, we need to add consciousness, i.e., to remember the history of past events. Suggest your own approach to implement the consciousness in machine. [5]

   Many answers and imaginative ideas can be considered correct, and debatable. So, any thing which is logical is considered as correct.