Name ____________________

Introduction to Expert Systems
EE 4785
Midterm Examination

20 March 1996,   10:40-11:30 C. S. T.

Problem 1	________	(33 pts)
Problem 2	________	(34 pts)
Problem 3	________	(33 pts)
Exam Total	________	(100 pts)

Alias ____________________

Good Luck!

Problem 1: Write a Prolog program so that goal `removeAt(S1,Positions,S2)` will unify `S2` with a structure which is like structure `S1` with components at positions specified in `Positions` removed, where `Positions` is a list of integers in increasing order. (33 pts)For example,

```
?- removeAt(a(b,c,d,e,f),[1,3],X).

X = a(c,e,f).

yes
?- removeAt(func(one,two),[],X).

X = func(one,two)

yes
?- removeAt(func(one,two),[2],X).

X = func(one)
yes
```

Problem 2: Rule `r1` below contains an error since `b` appears in both the antecedent and consequent. Given such a rule a backward-chaining inference engine might go into an infinite loop. Rules `r2` and `r3` exhibit a similar problem: to prove `c` true using `r3` the inference engine might use `r2` to prove `e` true, leading it to use `r3` (a second time) to prove `c` true, *ad infinitum.*

```
r1:if a and b then b.

r2:if c and d then e.
r3:if e and f then c.
```

Modify the backward chaining propositional logic expert system shell code (reproduced on the next page) so that an error message appears whenever an attempt is made to prove a proposition true which is in the consequent of a rule being evaluated. The error message should contain the rule in which the antecedent and consequent appear. (34 pts)

For example, `r1` might result in error message:

```
Error: Proposition b appearing in the antecedent
of rule r1, which is currently being evaluated, is also
a consequent of rule r1, also being evaluated.
```

The evaluation of `c` might result in error message:

```
Error: Proposition e appearing in the antecedent
of rule r3, which is currently being evaluated, is also
a consequent of rule r2, also being evaluated.
```

Show the modifications on the next page, below, or both places.

```
% Operand definitions.
%
:-op(900,xfx,:).        :-op(850,fx,if).        :-op(800,xfx,then).
:-op(750,xfy,or).       :-op(700,xfy,and).      :-op(650,fy,not).

% Remove facts from previous run, if any.
%
wipe:-!,abolish(found,2);true.

% deduce(Goal) succeeds if Goal is proven true.
%

% Goal previously found.
%
deduce(Goal):-found(Goal,From),!,From=userTrue.

% Goal using rule.
%
deduce(Goal):-
        Rule:if Antecedent then Goal,
        deduce(Antecedent),announce(Goal,true),!.

% Goal contains conjunction.
%
deduce(Goal1 and Goal2):-
        deduce(Goal1),deduce(Goal2).

% Goal contains disjunction.
%
deduce(Goal1 or Goal2):-
        ( deduce(Goal1) ; deduce(Goal2) ),!.

% Goal contains negation.
%
deduce(not Goal):-
        deduce(Goal),!,fail
        ;
        true.

% Ask user and add answer to database.
%
deduce(Goal):-askable(Goal,Question),
        askAndCheck(Question,x,yesNo,A),
        (
            A=true,Resp=userTrue  ;  A=false,Resp=userFalse
          ; A=unknown,Resp=userDN
        ),
        asserta(found(Goal,Resp)),!,Resp=userTrue.

% Check for unprovable assertions.
%
deduce(Goal):-
        atom(Goal),not(_:if _ then Goal),
        sOut<<"Assertion "<<Goal<<" is unprovable."<<nl,!,fail.

% Print a message when selected facts are proven.
%
announce(Goal,Truth):-
aGoalList(Goals),
member(Goal,Goals),
sOut<<"The proposition "<<Goal<<" has been proven "<<Truth<<"."<<nl.

announce(_,_).  % Succeed even if goal is not to be announced.
```

Problem 3: Answer each question below.

(*a*) How can atoms `op1`, `op2`, and `op3` be defined as operators so that expression: (11 pts)

```
a op1 b op1 c op3 d op2 e op2 f
```

is equivalent to

```
op3(op1(op1(a,b),c),op2(d,op2(e,f)))
```

(*b*) Each problem below is being considered for expert system solution. Describe the amount of structure in the knowledge needed to solve each problem. State any assumptions about the problem being solved, for example, "Coaching program makes strategic and tactical decisions based on current state of game and player's skills." (This assumption may be used in the solution.) Describe any other factors that would make the problems suitable or not suitable for expert system solution. (22 pts)

Playing chess.

Coaching football. (American or soccer).

Directing a play.