Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

app([],Y,Y).

app([H|T],Y,[H|Z]) :- app(T,Y,Z).

% ?- app([1,2], [3,4], Z). % mode: (+,+,-)

% ?- app([1,2], Y, [1,2,3,4]). % mode: (+,-,+)

% ?- app(X, [3,4], [1,2,3,4]). % mode: (-,+,+)

% ?- app(X, Y, [1,2,3]). % mode: (-,-,+)

% ?- cons(snoc(snoc(nil,3),4),5,Out) mode: (+,+,-)

% ?- cons(snoc(snoc(nil,3),4),Out,snoc(snoc(snoc(nil, 5), 3), 4)) mode: (+,-,+)

% ?- cons(Out,5,snoc(snoc(snoc(nil, 5), 3), 4)) mode: (-,+,+)

% ?- cons(Out,X,snoc(snoc(snoc(nil, 5), 3), 4)) mode: (-,-,+)

cons(nil,E,snoc(nil,E)).

cons(snoc(BL,N),E,snoc(BLN,N)) :- cons(BL,E,BLN).

% ?- toBl([1,3,7],Out) mode: (+,-)

toBl([],nil).

toBl([H|T],O) :- toBl(T,Bl),

cons(Bl,H,O).

% ?- snocF([1,2,3,4],5,Out). mode: (+,+,-)

% ?- snocF([1,2,3,4],Out,[1,2,3,4,5]). mode: (+,-,+)

% ?- snocF(Out,5,[1,2,3,4,5]). mode: (-,+,+)

% ?- snocF(X,Y,[1,2,3,4,5]). mode: (-,-,+)

snocF([],N,[N]).

snocF([H|T],N,[H|O]) :- snocF(T,N,O).

Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

% ?- fromBl(snoc(snoc(snoc(nil,1),3),7),Out). mode: (+,-)

```
fromBl(nil,[]).
fromBl(snoc(Bl,X),O) :- (fromBl(Bl,E)),
                        (snocF(E,X,O)).
```

% ?- numMt(node(5,node(3,empty,empty),empty),Out). mode: (+,-)

```
numMt(empty,1).
numMt(node(_,L,R),Es) :- numMt(L,LEs),
                         numMt(R,REs),
                         Es is LEs+REs.
```

% ?- numN(node(5,node(3,empty,empty),empty),Out). mode: (+,-)

```
numN(empty,0).
numN(node(_,L,R),Ns) :- numN(L,LNs),
                        numN(R,RNs),
                        Ns is 1+LNs+RNs.
```

% ?- insertL(5,node(8,empty,empty),Out). mode: (+,+,-)

% ?- insertL(Out,node(8,empty,empty),node(8,node(5,empty,empty),empty)). mode:(-,+,+)

% ?- insertL(5,Out,node(8,node(5,empty,empty),empty)). mode: (+,-,+)

% ?- insertL(X,Y,node(8,node(5,empty,empty),empty)). mode: (-,-,+)

```
insertL(X,empty,node(X,empty,empty)).
insertL(X,node(N,L,R),node(N,New,R)) :- insertL(X,L,New).
```

Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

% ?- insertR(X,Y,node(8,empty,node(5,empty,empty))). mode: (-,-,+)

% ?- insertR(5,Out,node(8,empty,node(5,empty,empty))). mode: (+,-,+)

% ?- insertR(Out,node(8,empty,empty),node(8,empty,node(5,empty,empty))). mode: (-,+,+)

% ?- insertR(5,node(8,empty,empty),Out). mode: (+,+,-)

```
insertR(X,empty,node(X,empty,empty)).
insertR(X,node(N,L,R),node(N,L,New))  :- insertR(X,R,New).
```

% ?- sumN(node(5,node(3,empty,empty),empty),Out). mode: (+,-)

```
sumN(empty,0).
sumN(node(N,R,L),O) :- sumN(R,SumR),
                       sumN(L,SumL),
                       O is N+SumL+SumR.
```

% ?- inOrd(node(2,node(1,empty,empty),node(3,empty,empty)),Out). mode: (+,-)

```
inOrd(empty,[]).
inOrd(node(N,L,R),O) :- inOrd(L,GoL),
                            inOrd(R,GoR),
                        app(GoL,[N],O1),
                        app(O1,GoR,O).
```

% ?- numEs(node2(7,node2(3,leaf(1),leaf(2)),node2(3,leaf(1),leaf(2))),Out). mode: (+,-)

```
numEs(leaf(_),1).
numEs(node2(_,L,R),O) :- numEs(L,LEs),
                             numEs(R,REs),
                         O is 1+LEs+REs.
```

Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

% ?- sumN2(node2(7,node2(3,leaf(1),leaf(2)),node2(3,leaf(1),leaf(2))),Out). mode: (+,-)

```
sumN2(leaf(N),N).
sumN2(node2(N,R,L),O) :- sumN2(R,SumR),
                         sumN2(L,SumL),
                         O is N+SumL+SumR.
```

% ?- inOrd2(node2(7,node2(3,leaf(1),leaf(2)),node2(3,leaf(1),leaf(2))),Out). mode: (+,-)

```
inOrd2(leaf(N),[N]).
inOrd2(node2(N,L,R),O) :- inOrd2(L,GoL),
                          inOrd2(R,GoR),
                          app(GoL,[N],O1),
                          app(O1,GoR,O).
```

% conv21(node2(7,node2(3,leaf(1),leaf(2)),node2(3,leaf(1),leaf(2))),Out). mode: (+,-)

% the mode: (-,+) below only works when there are 2 children

% conv21(Out,node(3,node(1,empty,empty),node(2,empty,empty))).

```
conv21(leaf(N),node(N,empty,empty)).
conv21(node2(N,L,R),node(N,LO,RO)) :- conv21(L,LO),
                                      conv21(R,RO).
```

% ?- toBl_It([1,2,3,4],X). mode: (+,-)

```
toBl_It(L,O) :- toBl_H(L,nil,O).
toBl_H([],A,A).
toBl_H([H|T],A,Bl) :- toBl_H(T,snoc(A,H),Bl).
```

Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

% ?- fromBl_It(snoc(snoc(snoc(nil,1),2),3),O). mode: (+,-)

```
fromBl_It(Bl,O) :- fromBl_H(Bl,[],O).

fromBl_H(nil,A,A).

fromBl_H(snoc(L,X),A,RL) :- fromBl_H(L,[X|A],RL).
```

% ?- sumN_It(node(2,node(1,empty,empty),node(3,empty,empty)),Out). mode: (+,-)

```
sumN_It(T,O) :- sumN_H([T],0,O).

sumN_H([],A,A).

sumN_H([empty|Ts],A,Sn) :- sumN_H(Ts,A,Sn).

sumN_H([node(N,L,R)|Ts],A,Sn) :- AN is A+N,
                                 sumN_H([L,R|Ts],AN,Sn).
```

% ?- numE_It(node(2,node(1,empty,empty),node(3,empty,empty)),Out). mode: (+,-)

```
numE_It(T,O) :- numE_H([T],0,O).

numE_H([],A,A).

numE_H([empty|Ts],A,En) :- A1 is A+1, numE_H(Ts,A1,En).

numE_H([node(_,L,R)|Ts],A,En) :- numE_H([L,R|Ts],A,En).
```

% ?- numN_It(node(2,node(1,empty,empty),node(3,empty,empty)),Out). mode: (+,-)

```
numN_It(T,O) :- numN_H([T],0,O).

numN_H([],A,A).

numN_H([empty|Ts],A,Nn) :- numN_H(Ts,A,Nn).

numN_H([node(_,L,R)|Ts],A,Nn) :- A1 is A+1, numN_H([L,R|Ts],A1,Nn).
```

Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

% ?- sumN2_It(node2(7,node2(3,leaf(1),leaf(2)),node2(3,leaf(1),leaf(2))),Out). mode: (+,-)

sumN2_It(T,O) :- sumN2_H([T],0,O).

sumN2_H([],A,A).

sumN2_H([leaf(N)|Ts],A,Sn) :- AN is A+N,

sumN2_H(Ts,AN,Sn).

sumN2_H([node2(N,L,R)|Ts],A,Sn) :- AN is A+N,

sumN2_H([L,R|Ts],AN,Sn).

% ?- inOrd2_It(node2(7,node2(3,leaf(1),leaf(2)),node2(3,leaf(1),leaf(2))),Out). mode: (+,-)

inOrd2_It(T2,O) :- inOrd2_H([T2],[],O).

inOrd2_H([],A,A).

inOrd2_H([leaf(N)|Ts],A,IO) :- inOrd2_H(Ts,[N|A],IO).

inOrd2_H([node2(N,L,R)|Ts],A,IO) :- inOrd2_H([R,leaf(N),L|Ts],A,IO).

% less than function with infinity

% ?- isA_lt_B(fin(1),fin(2)). mode: (+,+) (I included this cause it is the only one.)

isA_lt_B(neginf,fin(_)).

isA_lt_B(fin(N),fin(M)) :- N<M.

isA_lt_B(fin(_),posinf).

Eric Smrkovsky
10/23/2019
CSci 117
Lab 9

% ?-
bst_H(neginf,posinf,node(10,node(5,node(3,empty,empty),node(8,empty,empty)),node(15,empty,empty)),Out). mode: (+,+,+,-)

```
bst_H(_,_,empty,true).

bst_H(Lo,Hi,node(N,L,R),B) :- isA_lt_B(Lo,fin(N)),
                              isA_lt_B(fin(N),Hi),
                              bst_H(Lo,fin(N),L,B),
                              bst_H(fin(N),Hi,R,B).
```

% ?-
bst(node(10,node(5,node(3,empty,empty),node(8,empty,empty)),node(15,empty,empty)),Out). mode: (+,-)

```
bst(empty,false).

bst(node(N,L,R),B) :- bst_H(neginf,posinf,node(N,L,R),B),!.

bst(_,false).
```

% ?-
bst2_H(neginf,posinf,node2(15,node2(10,leaf(5),leaf(12)),node2(20,leaf(18),leaf(25))),Out). mode: (+,+,+,-)

```
bst2_H(Lo,Hi,leaf(N),true) :- isA_lt_B(Lo,fin(N)),
                              isA_lt_B(fin(N),Hi).

bst2_H(Lo,Hi,node2(N,L,R),B) :- isA_lt_B(Lo,fin(N)),
                                isA_lt_B(fin(N),Hi),
                                bst2_H(Lo,fin(N),L,B),
                                bst2_H(fin(N),Hi,R,B).
```

% ?- bst2(node2(15,node2(10,leaf(5),leaf(12)),node2(20,leaf(18),leaf(25))),Out). mode: (+,-)

```
bst2(leaf(_),false).

bst2(node2(N,L,R),B) :- bst2_H(neginf,posinf,node2(N,L,R),B),!.

bst2(_,false).
```