

A4-sol  
(win 2023)

① a) Denote:

$$s(x) = \text{smart}(x)$$

$$h(x) = \text{hard-working}(x)$$

$$g(x) = \text{graduate\_studies}(x)$$

We have:

$$\begin{aligned} & ((s(x) \wedge h(x)) \rightarrow g(x)) \wedge \\ & ((s(x) \wedge \neg h(x)) \rightarrow \neg g(x)) \\ \equiv & (\neg(s(x) \wedge h(x)) \vee g(x)) \wedge \\ & (\neg(s(x) \wedge \neg h(x)) \vee \neg g(x)) \\ \equiv & (\neg s(x) \vee \neg h(x) \vee \underline{g(x)}) \wedge \\ & (\neg s(x) \vee \underline{h(x)} \vee \neg g(x)) \end{aligned}$$

one non-negated term

$$\textcircled{b} \equiv ((s(x) \wedge h(x)) \rightarrow g(x)) \wedge ((s(x) \wedge g(x)) \rightarrow h(x))$$

Propog:

$$g(x) :- s(x), h(x).$$

$$h(x) :- s(x), g(x).$$

②    ③

1.  $\text{insert}(X, L, [X|L]).$
  2.  $\text{insert}(X, [H|L], [H|L1]) :- \text{insert}(X, L, L1).$
  3.  $\text{permute}([], []).$
  4.  $\text{permute}([H|T], P) :- \text{permute}(T, P1), \text{insert}(H, P1, P).$
- $\begin{matrix} \overline{\uparrow} & \overline{\uparrow} \\ \text{elem} & \text{list.} \end{matrix}$

$\text{permute}([a,b], Y).$

④ |  $H = a$   
 $T = [b]$

$\text{permute}([b], P1), \text{insert}(a, P1, Y).$

false

④ |  $H = b$   
 $T = []$

$\text{permute}([], P2), \text{insert}(b, P2, P1), \text{insert}(a, P1, Y).$

③ |  $P2 = [] \Rightarrow$  then permute is finished.

$\text{insert}(b, [], P1), \text{insert}(a, P1, Y).$

① |  $X = b$   
 $L = []$   
 $P1 = [b]$

$\Rightarrow [b|[ ]] = [b].$

$\text{insert}(a, [b], Y).$

$X = a$   
 $L = [b]$

$Y = [a, b];$

② |  $X = a$   
 $H = b$   
 $L = []$

$Y = [b|[ ]]$

$\text{insert}(a, [], L1).$

① |  $X = a$   
 $L = []$   
 $L1 = [a]$

$Y = [b, a];$

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1.  $\text{insert}(X, L, [X|L])$ .
2.  $\text{insert}(X, [H|L], [H|L1]) :- \text{insert}(X, L, L1)$ .
3.  $\text{permute}([], [])$ .
4.  $\text{permute}([H|T], P) :- \text{permute}(T, P1), \text{insert}(H, P1, P)$ .

$\text{permute}(Y, [a, b])$ .

④ |  $Y = [H|T]$   
 $P = [a, b]$

$\text{permute}(T, P1), \text{insert}(H, P1, [a, b])$ .

$T = []$   
 $P1 = []$  ③

④  $T = [H1|T1]$

$\text{insert}(H, [], [a, b])$ .

backtrack

$\text{permute}(T1, P2), \text{insert}(H1, P2, P1),$   
 $\text{insert}(H, P1, [a, b])$

$T1 = []$   
 $P2 = []$  ③

④

nothing to match,  
+ traceback.

$\text{insert}(H1, [], P1), \text{insert}(H, P1, [a, b])$ .

① |  $P1 = [H1]$

$\text{insert}(H, [H1], [a, b])$ .

$H = a$   
 $H1 = b$  ①

②  $H1 = [a|L1]$   
 $L1 = []$

$Y = [a, b];$

$\text{insert}(H, L1, [b])$ .

$H = b$   
 $L = []$  ①

②

$Y = [b, a];$

$\text{insert}(H, L2, [])$ .

backtrack

...  
 $\text{permute}(T1, P2)$   
will generate  
infinitely many  
solutions, all of  
which will fail  
 $\text{insert}(..., [a, b])$ .

⑤

1. insert(X, L, [X|L]).
2. insert(X, [H|L], [H|L1]) :- insert(X, L, L1).
3. permute([], []).
4. permute([H|T], P) :- permute(T, P1), insert(H, P1, P).

5. not(X) :- X, !, fail.
6. not(-).

not(permute(Y, []).

⑤ | ⑥  
permute(Y, [], !, fail.

③ | Y = []

!, fail

fail

backtrack

False

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```
magic_square(X) :- permutation([1,2,3,4,5,6,7,8,9],X),  
    X = [X1,X2,X3,X4,X5,X6,X7,X8,X9],  
    15 is X1+X2+X3,  
    15 is X4+X5+X6,  
    15 is X7+X8+X9,  
    15 is X1+X4+X7,  
    15 is X2+X5+X8,  
    15 is X3+X6+X9,  
    15 is X1+X5+X9,  
    15 is X3+X5+X7.
```

```
?- magic_square(X).  
X = [2, 7, 6, 9, 5, 1, 4, 3, 8] ;  
X = [2, 9, 4, 7, 5, 3, 6, 1, 8] ;  
X = [4, 3, 8, 9, 5, 1, 2, 7, 6] ;  
X = [4, 9, 2, 3, 5, 7, 8, 1, 6] ;  
X = [6, 1, 8, 7, 5, 3, 2, 9, 4] ;  
X = [6, 7, 2, 1, 5, 9, 8, 3, 4] ;  
X = [8, 1, 6, 3, 5, 7, 4, 9, 2] ;  
X = [8, 3, 4, 1, 5, 9, 6, 7, 2] ;  
false.
```