Questions:

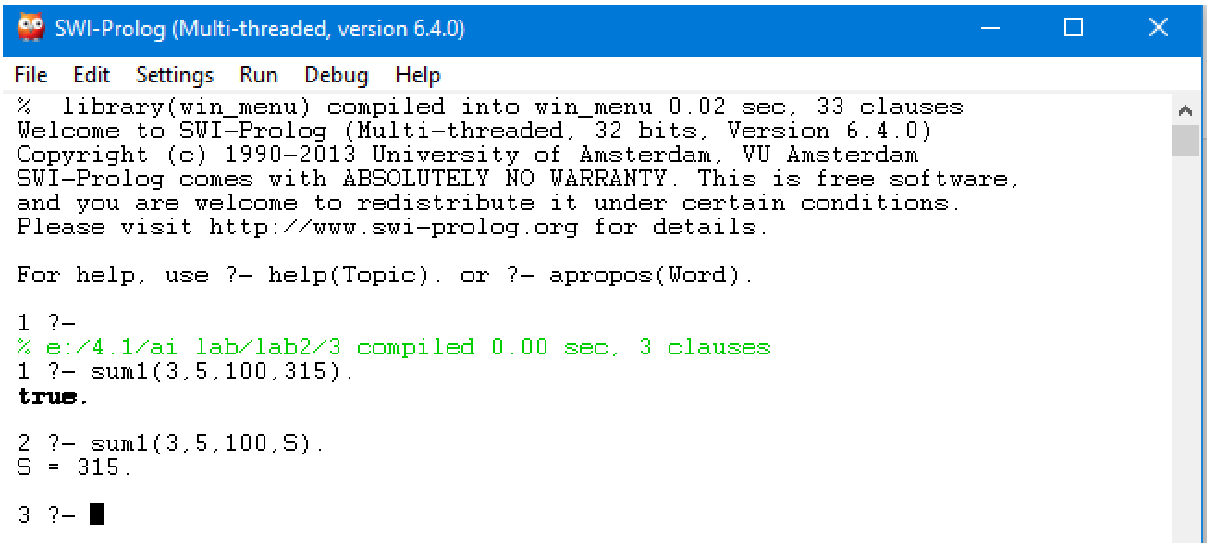
1) **Define a recursive procedure in Python and in Prolog to find the sum of 1st n terms of an equal-interval series given the 1st term and the interval.**
2) **Define a recursive procedure in Python and in Prolog to find the length of a path between two vertices of a directed weighted graph.**
3) **Modify the Python and Prolog codes demonstrated above to find h_2 and h_3 discussed above.**

Solution to the question no 1

The demonstrated Prolog code to find the sum is as below:

```
sum1(1,_,F,F):-!.
sum1(N,I,F,S):-N>0, N1 is N-1, sum1(N1,I,F,S1) , S is S1+F+N1*I.
```

A sample of input and output is as below:


SWI-Prolog (Multi-threaded, version 6.4.0)
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```
%  library(win_menu) compiled into win_menu 0.02 sec, 33 clauses
Welcome to SWI-Prolog (Multi-threaded, 32 bits, Version 6.4.0)
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1 ?-
% e:/4.1/ai lab/lab2/3 compiled 0.00 sec, 3 clauses
1 ?- sum1(3,5,100,315).
true.

2 ?- sum1(3,5,100,S).
S = 315.

3 ?- 
```

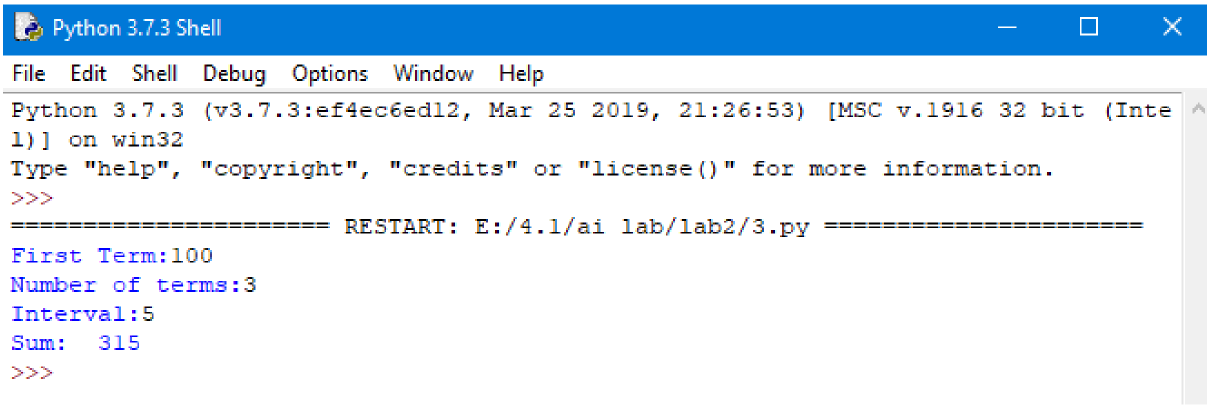
The demonstrated Python code to find sum is as below:

```
def sum(n,i,f):
    if(n == 0):
         return 0
    elif(n >= 1):
        return sum(n-1,i,f)+f+(n-1)*i

#main
fterm = int(input('First Term:'))
numterm = int(input('Number of terms:'))
inte = int(input('Interval:'))
total = sum(numterm,fterm,inte)

print('Sum: ', total)
```

A sample of input and output is as below:



```
Python 3.7.3 (v3.7.3:ef4ec6ed12, Mar 25 2019, 21:26:53) [MSC v.1916 32 bit (Inte
l)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>> 
===================== RESTART: E:/4.1/ai lab/lab2/3.py =====================
First Term:100
Number of terms:3
Interval:5
Sum:  315
>>> 
```

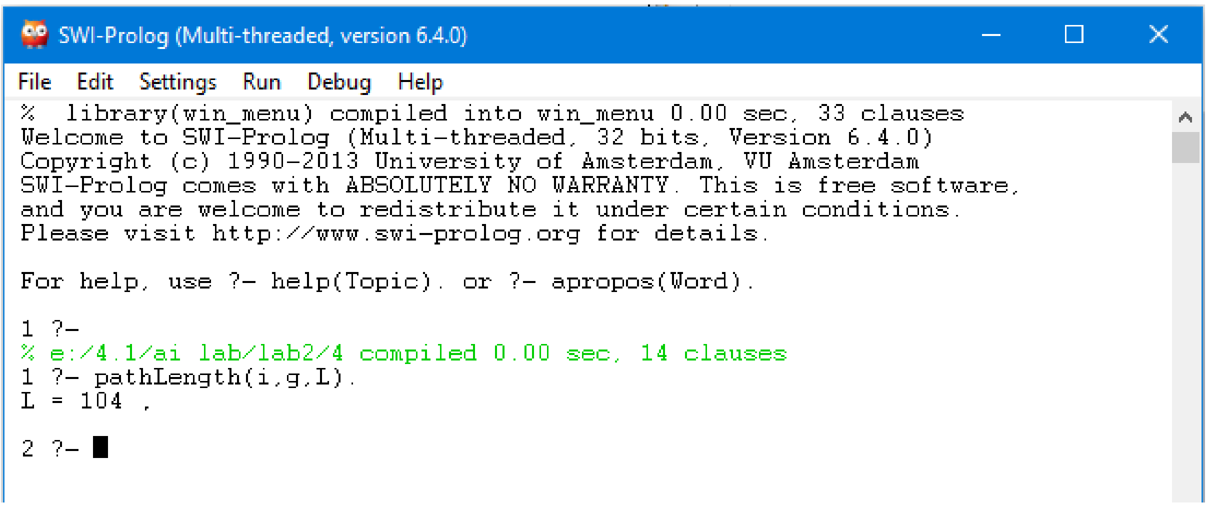
Solution to the question no 2

The demonstrated Prolog code is below:

neighbor(i,a,35). neighbor(i,b,45). neighbor(a,c,22).
neighbor(a,d,32). neighbor(b,d,28). neighbor(b,e,36).
neighbor(b,f,27). neighbor(c,d,31). neighbor(c,g,47).
neighbor(d,g,30). neighbor(e,g,26).

pathLength(X,Y,L):- neighbor(X,Y,L),!.
pathLength(X,Y,L):- neighbor(X,Z,L1), pathLength(Z,Y,L2), L is L1+L2.

A sample of input and output is as below: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```
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1 ?-
% e:/4.1/ai lab/lab2/4 compiled 0.00 sec, 14 clauses
1 ?- pathLength(i,g,L).
L = 104 .

2 ?- 
```
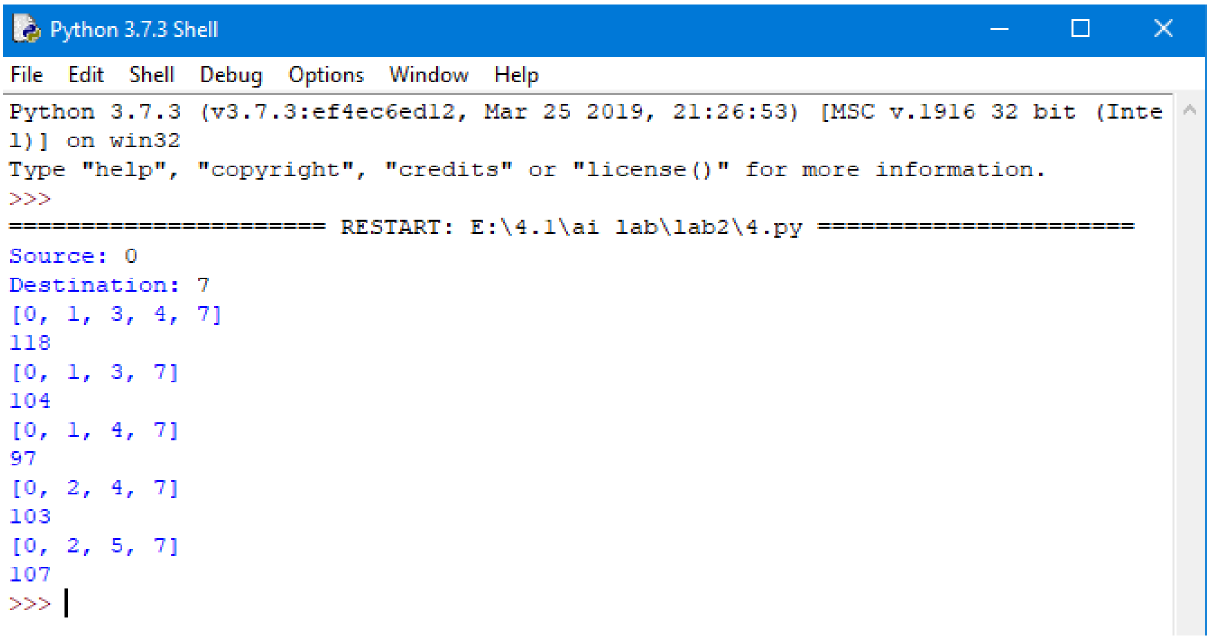

The demonstrated Python code is below:

```
from collections import defaultdict

def dfs(source,dest,visited,path):
    visited[source]= True
    path.append(source)

    if source == dest:
        total =0
        print(path)
        l = len(path)
        for i in range(l-1):
            total += graph[path[i]][path[i+1]]

        print(total)

    else:
        for i in graph[source]:
            if visited[i] == False:
                dfs(i,dest,visited,path)
    path.pop()
    visited[source]=False


graph = defaultdict(dict)
graph[0][1]=35
graph[0][2]=45
graph[1][3]=22
graph[1][4]=32
graph[2][4]=28
graph[2][5]=36
graph[2][6]=27
graph[4][7]=30
graph[3][4]=31
graph[3][7]=47
graph[4][7]=30
graph[5][7]=26

source = int(input("Source: "))
dest = int(input("Destination: "))

visited = [False]*8
path=[]
dfs(source,dest, visited, path)
```

A sample of input and output is as below:



```
Python 3.7.3 (v3.7.3:ef4ec6ed12, Mar 25 2019, 21:26:53) [MSC v.1916 32 bit (Inte
l)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>> 
====================== RESTART: E:\4.1\ai lab\lab2\4.py ======================
Source: 0
Destination: 7
[0, 1, 3, 4, 7]
118
[0, 1, 3, 7]
104
[0, 1, 4, 7]
97
[0, 2, 4, 7]
103
[0, 2, 5, 7]
107
>>> 
```

Solution to the question no 3

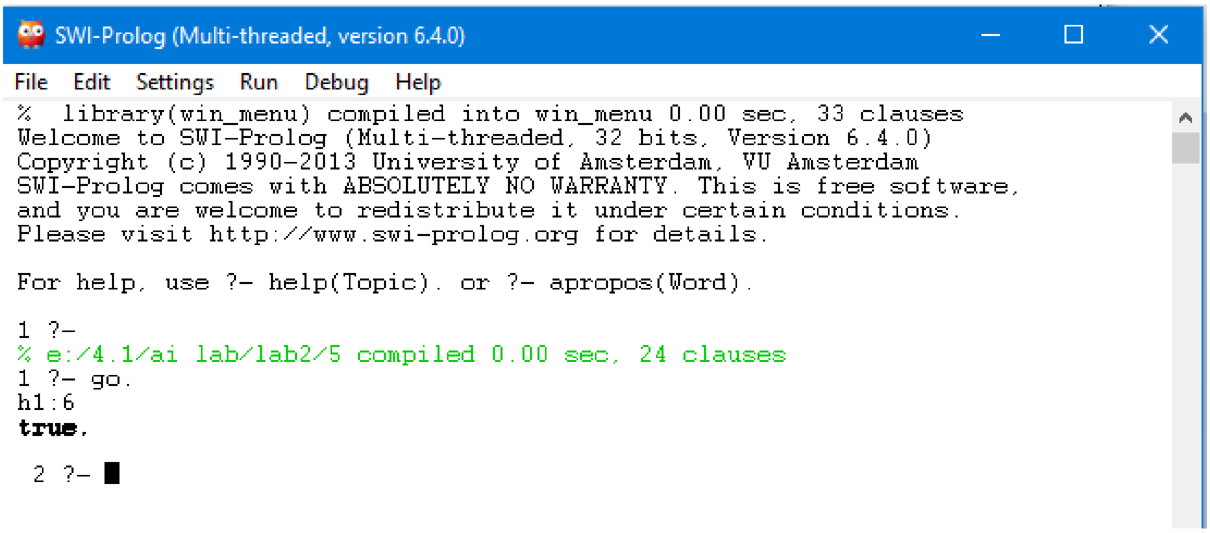
The demonstrated Prolog code to find heuristic function(h1) of 8-puzzle problem is as below:
gtp(1,1,1). gtp(2,1,2). gtp(3,1,3). gtp(4,2,3). gtp(5,3,3). gtp(6,3,2). gtp(7,3,1). gtp(8,2,1).
gblnk(2,2).

tp(1,1,2). tp(2,1,3). tp(3,2,1). tp(4,2,3). tp(5,3,3). tp(6,2,2). tp(7,3,2). tp(8,1,1). blnk(3,1).

go:- catchH(1,0,H), write('h1:'),write(H).

catchH(9,X,X):-!.
catchH(T,X,Y):- check(T,V), X1 is X+V, T1 is T+1, catchH(T1,X1,Y).
check(T,V):- tp(T,A,B), gtp(T,C,D), A=C, B=D, V is 0, !.
check(_,1):-!.

A sample of input and output is as below:


SWI-Prolog (Multi-threaded, version 6.4.0)
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```
% library(win_menu) compiled into win_menu 0.00 sec, 33 clauses
Welcome to SWI-Prolog (Multi-threaded, 32 bits, Version 6.4.0)
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For help, use ?- help(Topic). or ?- apropos(Word).

1 ?-
% e:/4.1/ai lab/lab2/5 compiled 0.00 sec, 24 clauses
1 ?- go.
h1:6
true.

 2 ?- 
```

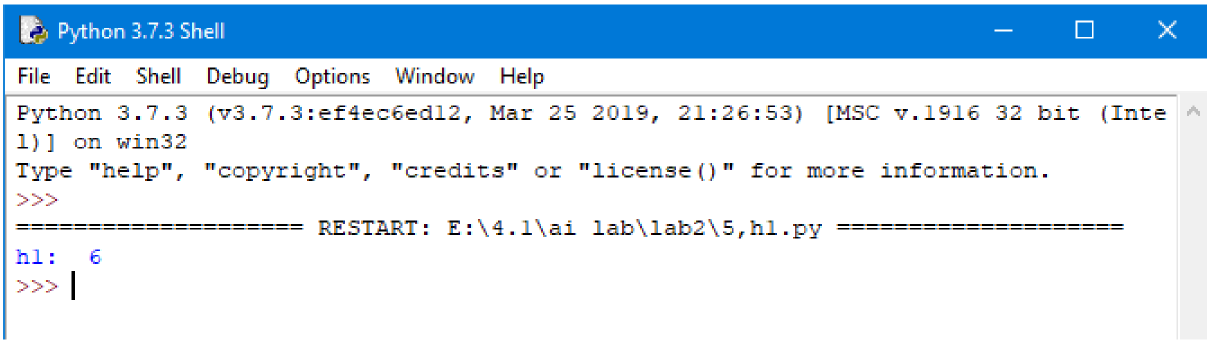
The demonstrated Python code to find heuristic function(h1) of 8-puzzle problem is as below:

```
gtp=[(1,1,1), (2,1,2), (3,1,3), (4,2,3), (5,3,3), (6,3,2), (7,3,1), (8,2,1)]
gblnk = (2,2)
tp=[(1,1,2), (2,1,3), (3,2,1), (4,2,3), (5,3,3), (6,2,2), (7,3,2), (8,1,1)]
blnk = (3,1)

# Procedure to find the number of mismatches
i,h=0,0

while(i<=7):
    if (gtp[i][1] != tp[i][1]) | (gtp[i][2] != tp[i][2]):
        h+=1
    i+=1
print("h1: ", h)
```

A sample of input and output is as below:



```
Python 3.7.3 (v3.7.3:ef4ec6ed12, Mar 25 2019, 21:26:53) [MSC v.1916 32 bit (Inte
l)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>> 
==================== RESTART: E:\4.1\ai lab\lab2\5,h1.py ====================
h1:  6
>>> 
```

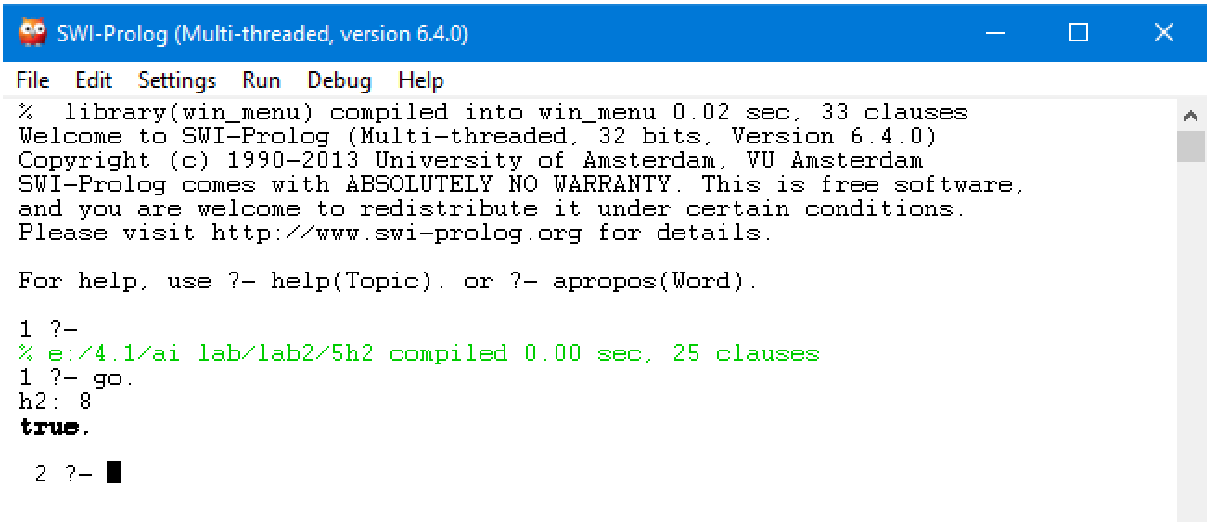
The demonstrated Prolog code to find heuristic function(h2) of 8-puzzle problem is as below:

```
gtp(1,1,1). gtp(2,1,2). gtp(3,1,3). gtp(4,2,3). gtp(5,3,3). gtp(6,3,2). gtp(7,3,1). gtp(8,2,1).
gblnk(2,2).
tp(1,1,2). tp(2,1,3). tp(3,2,1). tp(4,2,3). tp(5,3,3). tp(6,2,2). tp(7,3,2). tp(8,1,1). blnk(3,1).

go:- catcH(1,0,H), write('h1:'),write(H).

catcH(9,X,X):-!.
catcH(T,X,Y):- check(T,V), X1 is X+V, T1 is T+1, catcH(T1,X1,Y).
check(T,V):- tp(T,A,B), gtp(T,C,D), A=C, B=D, V is 0, !.
check(_,1):-!.
```

A sample of input and output is as below:


SWI-Prolog (Multi-threaded, version 6.4.0)
File Edit Settings Run Debug Help

```
%  library(win_menu) compiled into win_menu 0.02 sec, 33 clauses
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For help, use ?- help(Topic). or ?- apropos(Word).

1 ?-
% e:/4.1/ai lab/lab2/5h2 compiled 0.00 sec, 25 clauses
1 ?- go.
h2: 8
true.

 2 ?-
```
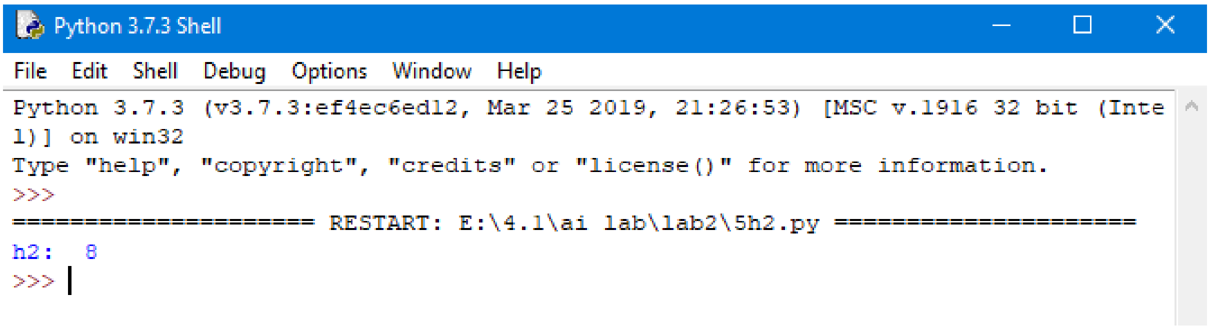

The demonstrated Python code to find heuristic function(h2) of 8-puzzle problem is as below:

```
gtp=[(1,1,1), (2,1,2), (3,1,3), (4,2,3), (5,3,3), (6,3,2), (7,3,1), (8,2,1)]
gblnk = (2,2)
tp=[(1,1,2), (2,1,3), (3,2,1), (4,2,3), (5,3,3), (6,2,2), (7,3,2), (8,1,1)]
blnk = (3,1)

# Procedure to find the number of movements

i,h=0,0
while(i<=7):
   if ((gtp[i][1] != tp[i][1])|(gtp[i][2] != tp[i][2])):
      h += abs(gtp[i][1] - tp[i][1])  + abs(gtp[i][2] - tp[i][2])
   i += 1
print('h2: ',h)
```

A sample of input and output is as below:

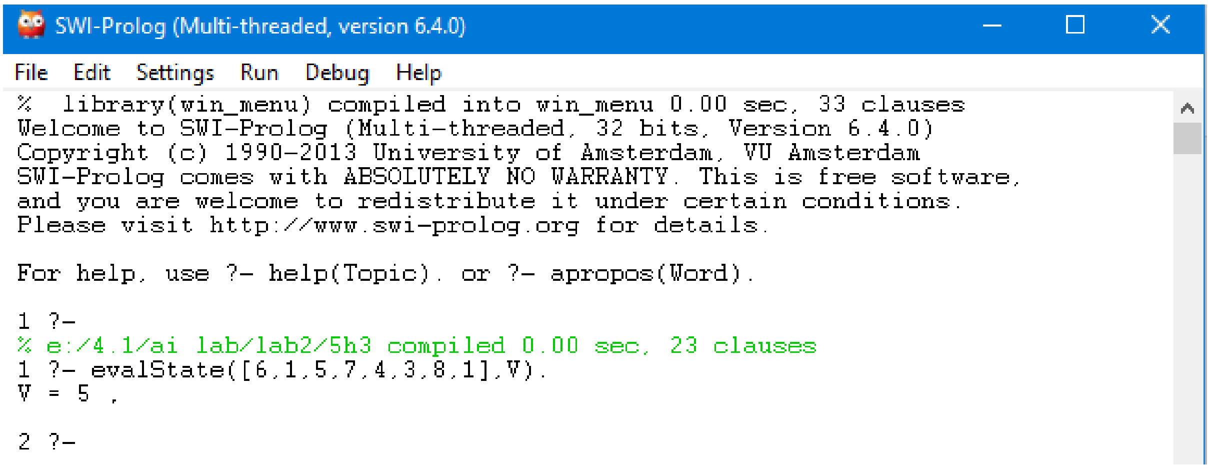


```
Python 3.7.3 (v3.7.3:ef4ec6ed12, Mar 25 2019, 21:26:53) [MSC v.1916 32 bit (Inte
l)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
===================== RESTART: E:\4.1\ai lab\lab2\5h2.py =====================
h2:  8
>>> 
```

The demonstrated Prolog code to find heuristic function(h3) of 8-queen problem is as below:

```
:-dynamic(hval/1).

/* Evaluates a 8-queens' state given as list of 8 digits */
evalState(L,V):- assert(hval(0)),hl(1,L), di_up(1,L),di_dn(1,L),hval(V),
              retractall(hval(_)).

hl(8,_):-!.  hl(I,L):- nthel(I,L,X), chk_incr(I,L,X), I1 is I+1, hl(I1,L).

chk_incr(8,_,_):-!.  chk_incr(I,L,X):- I1 is I+1, nthel(I1,L,Y),
                                do_incr(X,Y),chk_incr(I1,L,X).
do_incr(X,Y):- X=Y, incr_hval.  do_incr(_,_).

incr_hval:-hval(V), V1 is V+1, retract(hval(_)), assert(hval(V1)).

di_up(8,_):-!.  di_up(I,L):- nthel(I,L,X), chkup_incr(I,L,X,0), I1 is I+1,
                        di_up(I1,L).
chkup_incr(8,_,_,_):-!.
chkup_incr(I,L,X,K):- I1 is I+1, nthel(I1,L,Y), K1 is K+1,
                                  doup_incr(X,Y,K1), chkup_incr(I1,L,X,K1).
doup_incr(X,Y,K1):- X1 is X+K1, Y=X1, incr_hval.  doup_incr(_,_,_).

di_dn(8,_):-!.  di_dn(I,L):- nthel(I,L,X), chkdn_incr(I,L,X,0), I1 is I+1,
                        di_dn(I1,L).
chkdn_incr(8,_,_,_):-!.
chkdn_incr(I,L,X,K):- I1 is I+1, nthel(I1,L,Y), K1 is K+1,
dodn_incr(X,Y,K1), chkdn_incr(I1,L,X,K1).

dodn_incr(X,Y,K1):- X1 is X-K1, Y=X1, incr_hval.  dodn_incr(_,_,_).

% A procedure to find the nth element of a list
nthel(N,[_|T],El):- N1 is N-1, nthel(N1,T,El).
nthel(1,[H|_],H):-!.
```

A sample of input and output is as below:



```
%  library(win_menu) compiled into win_menu 0.00 sec, 33 clauses
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1 ?-
% e:/4.1/ai lab/lab2/5h3 compiled 0.00 sec, 23 clauses
1 ?- evalState([6,1,5,7,4,3,8,1],V).
V = 5 .

2 ?-
```
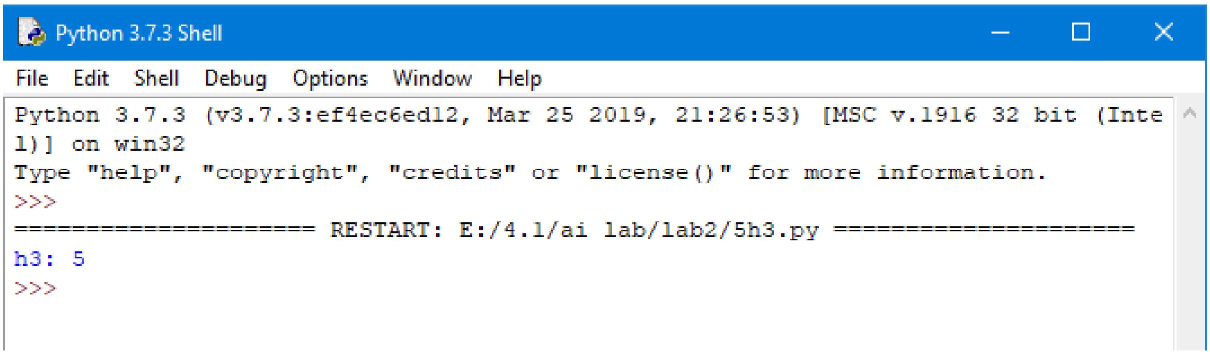

The demonstrated Python code to find heuristic function(h3) of 8-queen problem is as below:

```
#procedure to find out heuristic function(h3) for 8-Queens problem

state = [6,1,5,7,4,3,8,1]
total = 0

for i in range(len(state)):
    temp = state[i]

    for k in range(i+1, len(state),1):
        if(temp == state[k]):
            total +=1

    j = 1
    for k in range(i+1, len(state), 1):
        if((temp + j < len(state)) & (temp - j > -1)):
            if((state[k] == temp + j) | ( state[k] == temp - j)):
                total+=1
                state[k] = 9
        j+=1

    m = 1
    for k in range(i-1, -1, -1):
        if((temp + m < len(state)) & (temp - m > -1)):
            if((state[k] == temp + m) | (state[k] == temp - m)):
                total+=1
                state[k] = 9
        m+=1

print('h3:',total)
```

A sample of input and output is as below:



```
Python 3.7.3 (v3.7.3:ef4ec6ed12, Mar 25 2019, 21:26:53) [MSC v.1916 32 bit (Inte
l)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
===================== RESTART: E:/4.1/ai lab/lab2/5h3.py =====================
h3: 5
>>>
```