CSE 571 – Fall 2015

Project 3

1

14 a

The device d1 will be on and d2 will be off in the resulting state.

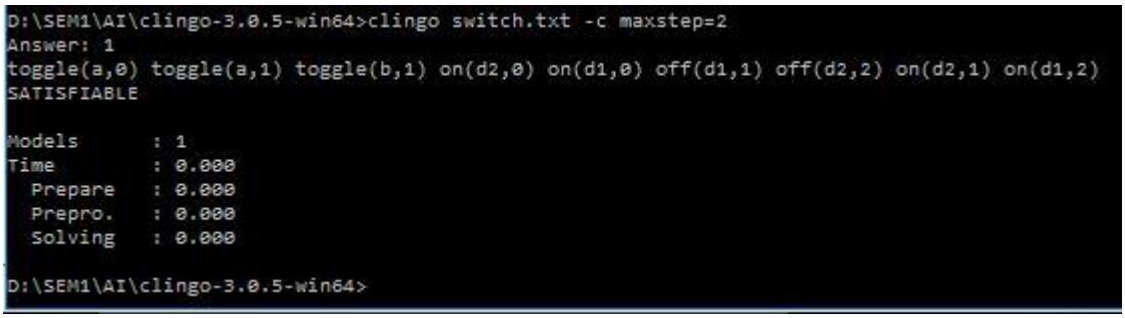
Lines included in the program:

```
:- off(d1,1).
:- off(d2,0).
toggle(a,0).
:-toggle(b,0).
toggle(a,1).toggle(b,1).
```

Output:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo switch.txt -c maxstep=2
Answer: 1
toggle(a,0) toggle(a,1) toggle(b,1) on(d2,0) on(d1,0) off(d1,1) off(d2,2) on(d2,1) on(d1,2)
SATISFIABLE

Models       : 1
Time         : 0.000
  Prepare    : 0.000
  Prepro.    : 0.000
  Solving    : 0.000

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:



14 b

The device d1 must have been on and d2 must have been of in the initial state.

Lines included in the program:

```
toggle(a,0).
:-toggle(b,0).
toggle(a,1).toggle(b,1).
:- not on(X,maxstep).
```

Output:

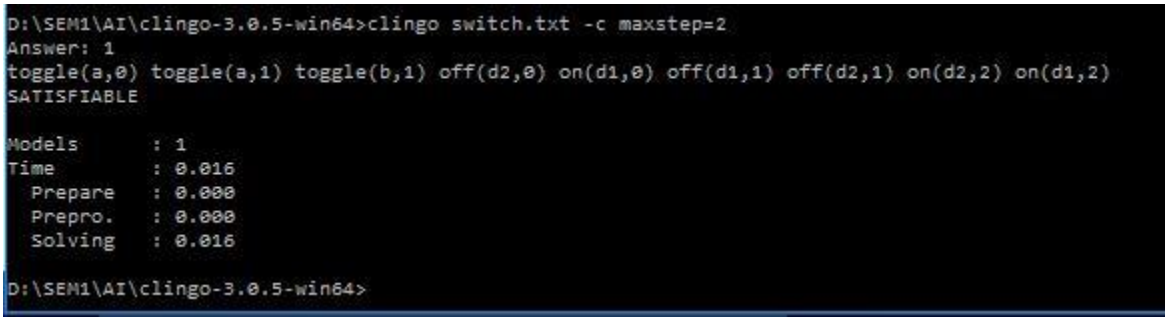
```
D:\SEM1\AI\clingo-3.0.5-win64>clingo switch.txt -c maxstep=2
Answer: 1
toggle(a,0) toggle(a,1) toggle(b,1) off(d2,0) on(d1,0) off(d1,1) off(d2,1) on(d2,2) on(d1,2)
```

SATISFIABLE

Models : 1
Time : 0.016
Prepare : 0.000
Prepro. : 0.000
Solving : 0.016

D:\SEM1\AI\clingo-3.0.5-win64>

Screenshot:



2

15

Minimum possible length = 2.

Lines included in the program:

```
:- off(X,0).
:- not off(X,maxstep).
:- not {toggle(SS,T):switch(SS)}1.
```

Output:

D:\SEM1\AI\clingo-3.0.5-win64>clingo switch.txt -c maxstep=2
Answer: 1
toggle(b,1) toggle(a,0) on(d2,0) on(d1,0) off(d1,1) off(d2,2) off(d1,2) on(d2,1)
SATISFIABLE

Models : 1+
Time : 0.016
Prepare : 0.000
Prepro. : 0.000
Solving : 0.016

D:\SEM1\AI\clingo-3.0.5-win64>

Screenshot:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo switch.txt -c maxstep=2
Answer: 1
toggle(b,1) toggle(a,0) on(d2,0) on(d1,0) off(d1,1) off(d2,2) off(d1,2) on(d2,1)
SATISFIABLE

Models       : 1+
Time         : 0.016
  Prepare    : 0.000
  Prepro.    : 0.000
  Solving    : 0.016

D:\SEM1\AI\clingo-3.0.5-win64>
```

3

16 a

Lines included in the program:

```
% initial state
on(1,2,0).
on(2,table,0).
on(3,4,0).
on(4,table,0).
on(5,6,0).
on(6,table,0).
```

No change was observed in the output due to this change.

Output:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo blocks.txt -c maxstep=3 -c grippers=2 0
Answer: 1
move(6,5,2) move(3,2,2) move(5,4,1) move(2,1,1) move(3,table,0) move(1,table,0)
SATISFIABLE

Models      : 1
Time        : 0.016
  Prepare   : 0.016
  Prepro.   : 0.000
  Solving   : 0.000

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo blocks.txt -c maxstep=3 -c grippers=2 0
Answer: 1
move(6,5,2) move(3,2,2) move(5,4,1) move(2,1,1) move(3,table,0) move(1,table,0)
SATISFIABLE

Models       : 1
Time         : 0.016
  Prepare    : 0.016
  Prepro.    : 0.000
  Solving    : 0.000

D:\SEM1\AI\clingo-3.0.5-win64>
```

16 b

Since goal conditions are not exogenous, these conditions on the paths of interest are represented as constraints. Initial states are exogenous and hence they can simply be represented as set of rules or facts as well. But for goal conditions this doesn't work. The output obtained is an incorrect long sequence of answers (plans).

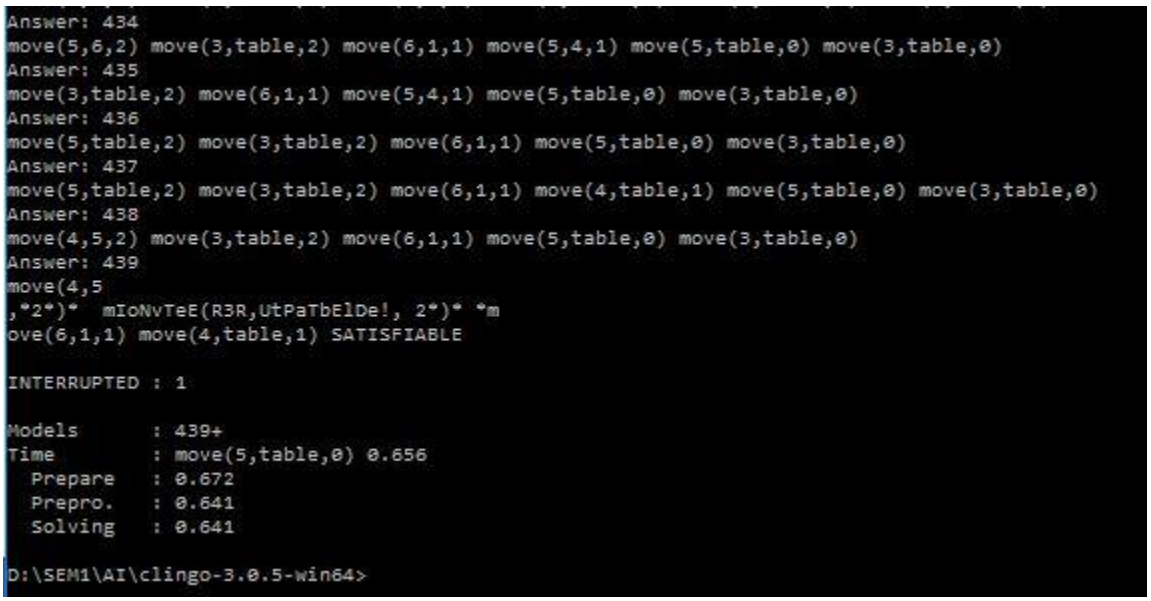
Lines included in the program:

```
on(3,2,maxstep).
on(2,1,maxstep).
on(1,table,maxstep).
on(6,5,maxstep).
on(5,4,maxstep).
on(4,table,maxstep).
```

Output:

```
move(3,table,2) move(6,1,1) move(5,4,1) move(5,table,0) move(3,table,0)
Answer: 436
move(5,table,2) move(3,table,2) move(6,1,1) move(5,table,0) move(3,table,0)
Answer: 437
move(5,table,2) move(3,table,2) move(6,1,1) move(4,table,1) move(5,table,0) move(3,table,0)
Answer: 438
move(4,5,2) move(3,table,2) move(6,1,1) move(5,table,0) move(3,table,0)
Answer: 439
move(4,5
,*2*)*  mIoNvTeE(R3R,UtPaTbElDe!, 2*)* *m
ove(6,1,1) move(4,table,1) SATISFIABLE

INTERRUPTED : 1

Models      : 439+
Time        : move(5,table,0) 0.656
  Prepare   : 0.672
  Prepro.   : 0.641
  Solving   : 0.641

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:



4

17

122 answers for **maxstep = 4** and size = 4

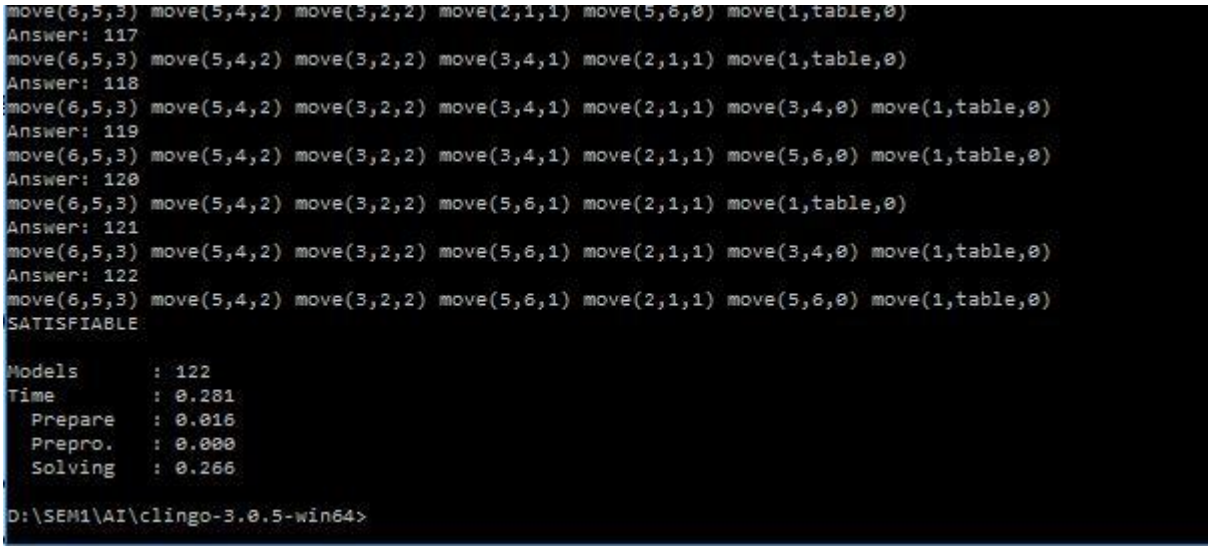
Lines included in the program:

```
% limit on table size
:- not {on(_,table,T)} size.

% if optimization is required over the 122 answers, this code has to be used. But as it is not mentioned in the
%question, I'm not assuming things.
% a block can't be moved to a location same as it's current location.
%:-move(B,B1,T), on(B,B1,T).
%
```

Output :

```
Answer: 119
move(6,5,3) move(5,4,2) move(3,2,2) move(3,4,1) move(2,1,1) move(5,6,0) move(1,table,0)
Answer: 120
move(6,5,3) move(5,4,2) move(3,2,2) move(5,6,1) move(2,1,1) move(1,table,0)
Answer: 121
move(6,5,3) move(5,4,2) move(3,2,2) move(5,6,1) move(2,1,1) move(3,4,0) move(1,table,0)
Answer: 122
move(6,5,3) move(5,4,2) move(3,2,2) move(5,6,1) move(2,1,1) move(5,6,0) move(1,table,0)
SATISFIABLE

Models       : 122
Time         : 1.297
  Prepare    : 0.000
  Prepro.    : 0.016
  Solving    : 1.281

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:



52 answers for **maxstep = 5** and size = 3.

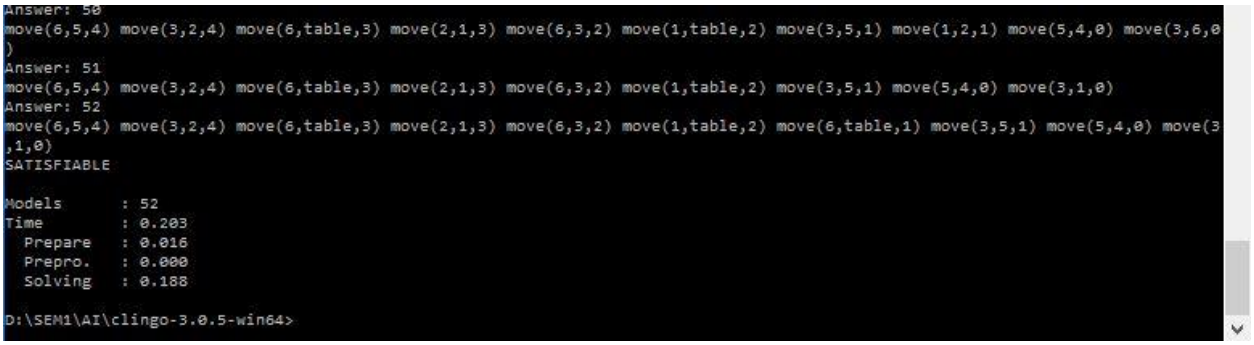
Output:

Answer: 47
move(3,2,4) move(2,1,3) move(3,6,2) move(1,table,2) move(6,5,1) move(3,table,1) move(5,4,0) move(3,1,0)
Answer: 48
move(3,2,4) move(3,6,3) move(2,1,3) move(3,6,2) move(1,table,2) move(6,5,1) move(3,table,1) move(5,4,0) move(3,1,0)
Answer: 49
move(6,5,4) move(3,2,4) move(6,table,3) move(2,1,3) move(6,3,2) move(1,table,2) move(3,5,1) move(5,4,0) move(3,6,0)
Answer: 50
move(6,5,4) move(3,2,4) move(6,table,3) move(2,1,3) move(6,3,2) move(1,table,2) move(3,5,1) move(1,2,1) move(5,4,0) move(3,6,0)
Answer: 51
move(6,5,4) move(3,2,4) move(6,table,3) move(2,1,3) move(6,3,2) move(1,table,2) move(3,5,1) move(5,4,0) move(3,1,0)
Answer: 52
move(6,5,4) move(3,2,4) move(6,table,3) move(2,1,3) move(6,3,2) move(1,table,2) move(6,table,1) move(3,5,1) move(5,4,0) move(3,1,0)
SATISFIABLE

Models : 52
Time : 0.203
Prepare : 0.016
Prepro. : 0.000
Solving : 0.188

D:\SEM1\AI\clingo-3.0.5-win64>

Screenshot:



5

21

No, the length of the plan remains 4**. This is under the assumption that telekinesis and walk can't be performed simultaneously.**

Remove:

Commented out all lines involving pushBox and introduced new action telekinesis.

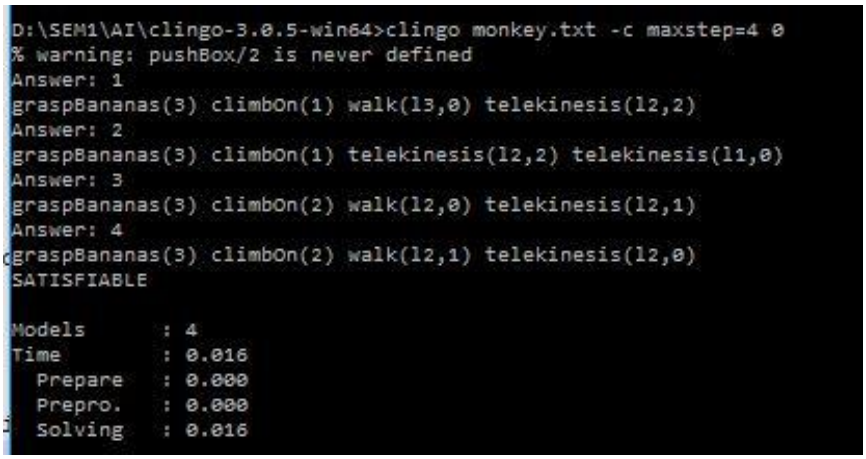
Add:

```
% telekinesis
loc(box,L,T+1) :- telekinesis(L,T).
loc(monkey,L,T+1) :- onBox(true,T), telekinesis(L,T).

%exogenous
{telekinesis(LL,T): location(LL)}.

:- telekinesis(L,T), climbOn(T).
:- telekinesis(L,T), graspBananas(T).
:- walk(L,T), telekinesis(L,T).
:- walk(L1,T), telekinesis(L,T).
```

Output:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo monkey.txt -c maxstep=4 0
% warning: pushBox/2 is never defined
Answer: 1
graspBananas(3) climbOn(1) walk(l3,0) telekinesis(l2,2)
Answer: 2
graspBananas(3) climbOn(1) telekinesis(l2,2) telekinesis(l1,0)
Answer: 3
graspBananas(3) climbOn(2) walk(l2,0) telekinesis(l2,1)
Answer: 4
graspBananas(3) climbOn(2) walk(l2,1) telekinesis(l2,0)
SATISFIABLE

Models      : 4
Time        : 0.016
  Prepare   : 0.000
  Prepro.   : 0.000
  Solving   : 0.016
```

Screenshot:



6

22

Minimum value of maxstep = 6. There are 2 plans possible for this length.

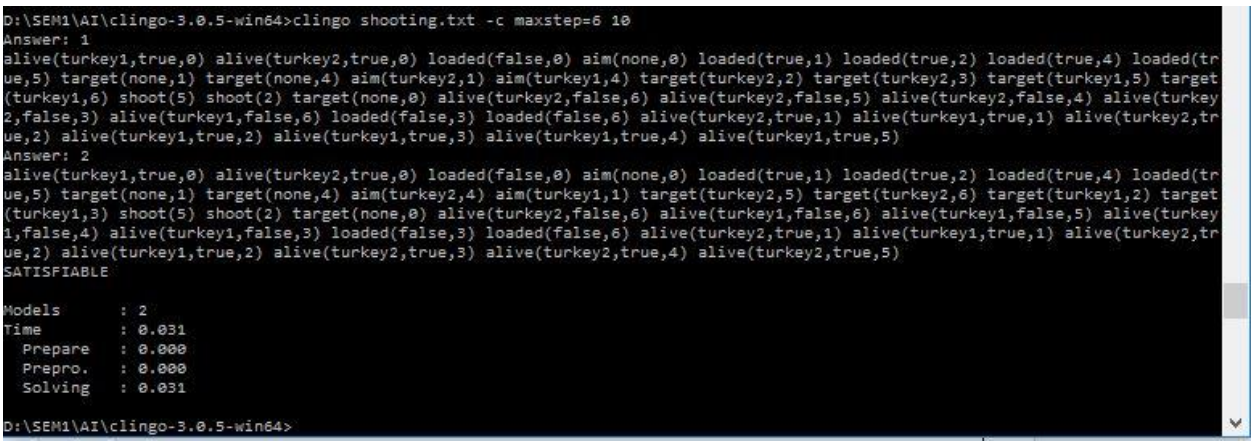
Add:

```
target(none,T):-aim(none,T).

% initial state
alive(turkey1,true,0).
alive(turkey2,true,0).
loaded(false,0).
aim(none,0).

% goal condition
:- not alive(X,false,maxstep).

#hide.
#show aim/2.
#show target/2.
#show shoot/1.
#show alive/3.
#show loaded/2.
```

Output:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo shooting.txt -c maxstep=6 10
Answer: 1
alive(turkey1,true,0) alive(turkey2,true,0) loaded(false,0) aim(none,0) loaded(true,1) loaded(true,2)
loaded(true,4) loaded(true,5) target(none,1) target(none,4) aim(turkey2,1) aim(turkey1,4) target(turkey2,2)
target(turkey2,3) target(turkey1,5) target(turkey1,6) shoot(5) shoot(2) target(none,0) alive(turkey2,false,6)
alive(turkey2,false,5) alive(turkey2,false,4) alive(turkey2,false,3) alive(turkey1,false,6) loaded(false,3)
loaded(false,6) alive(turkey2,true,1) alive(turkey1,true,1) alive(turkey2,true,2) alive(turkey1,true,2)
alive(turkey1,true,3) alive(turkey1,true,4) alive(turkey1,true,5)
Answer: 2
alive(turkey1,true,0) alive(turkey2,true,0) loaded(false,0) aim(none,0) loaded(true,1) loaded(true,2)
loaded(true,4) loaded(true,5) target(none,1) target(none,4) aim(turkey2,4) aim(turkey1,1) target(turkey2,5)
target(turkey2,6) target(turkey1,2) target(turkey1,3) shoot(5) shoot(2) target(none,0) alive(turkey2,false,6)
alive(turkey1,false,6) alive(turkey1,false,5) alive(turkey1,false,4) alive(turkey1,false,3) loaded(false,3)
loaded(false,6) alive(turkey2,true,1) alive(turkey1,true,1) alive(turkey2,true,2) alive(turkey1,true,2)
alive(turkey2,true,3) alive(turkey2,true,4) alive(turkey2,true,5)
SATISFIABLE

Models      : 2

Time        : 0.031
  Prepare   : 0.000
  Prepro.   : 0.000
  Solving   : 0.031

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:



7

23

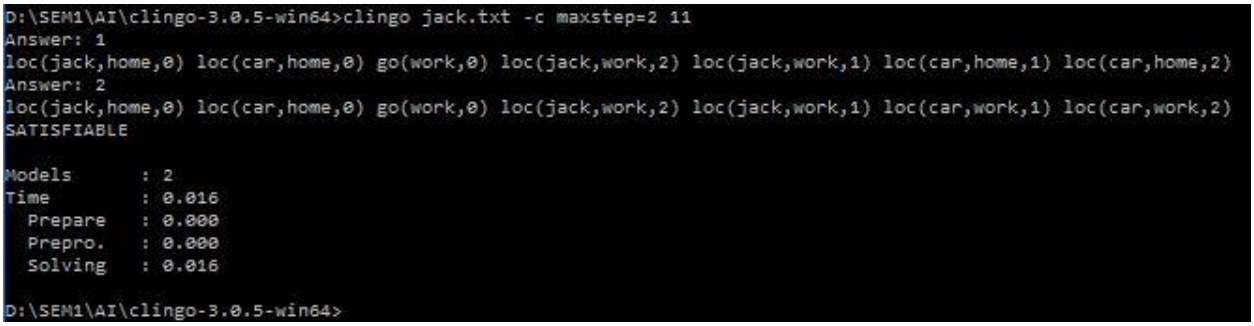
Add:

```
%initial conditions
loc(jack,home,0).
loc(car,home,0).
go(work,0).

%goal conditions
:- not loc(jack,work,maxstep).

#hide.
#show go/2.
#show loc/3.
```

Output:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo jack.txt -c maxstep=2 11
Answer: 1
loc(jack,home,0) loc(car,home,0) go(work,0) loc(jack,work,2) loc(jack,work,1) loc(car,home,1) loc(car,home,2)
Answer: 2
loc(jack,home,0) loc(car,home,0) go(work,0) loc(jack,work,2) loc(jack,work,1) loc(car,work,1) loc(car,work,2)
SATISFIABLE

Models       : 2
Time         : 0.016
  Prepare    : 0.000
  Prepro.    : 0.000
  Solving    : 0.016

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:



8

24

2 histories of length 2 satisfy the given requirements.

Add:

~~onTable(false,ST) :- level(leftEnd,H,ST), level(rightEnd,H1,ST), H!=H1.~~
onTable(f,ST) :- level(leftEnd,H,ST), level(rightEnd,H1,ST), H!=H1.

%initial condition
level(leftEnd,low,0).
level(rightEnd,low,0).

%goal condition
:- not onTable(t,maxstep).
:- not level(E,high,maxstep).

#hide.
#show lift/2.
#show level/3.
#show onTable/2.

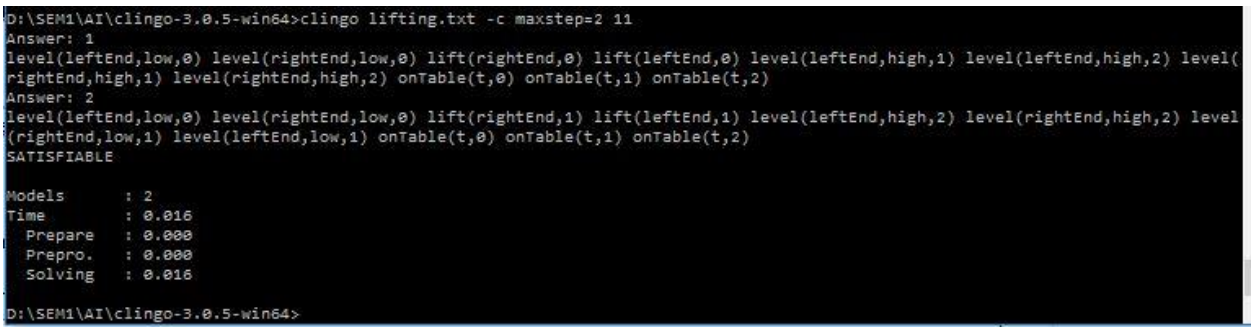
Output:

D:\SEM1\AI\clingo-3.0.5-win64>clingo lifting.txt -c maxstep=2 11
Answer: 1
level(leftEnd,low,0) level(rightEnd,low,0) lift(rightEnd,0) lift(leftEnd,0) level(leftEnd,high,1) level(leftEnd,high,2) level(rightEnd,high,1) level(rightEnd,high,2) onTable(t,0) onTable(t,1) onTable(t,2)
Answer: 2
level(leftEnd,low,0) level(rightEnd,low,0) lift(rightEnd,1) lift(leftEnd,1) level(leftEnd,high,2) level(rightEnd,high,2) level(rightEnd,low,1) level(leftEnd,low,1) onTable(t,0) onTable(t,1) onTable(t,2)
SATISFIABLE

Models : 2
Time : 0.000
Prepare : 0.000
Prepro. : 0.000
Solving : 0.000

D:\SEM1\AI\clingo-3.0.5-win64>

Screenshot:



9

25

8 histories of length 3 are possible from the given state.

Add:

```
%initial condition
right(0).

#hide.
#show right/1.
#show left/1.
```

Output:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo pendulum.txt -c maxstep=3 10
Answer: 1
right(0) right(1) right(3) left(2)
Answer: 2
right(0) right(1) left(2) left(3)
Answer: 3
right(0) right(1) right(2) left(3)
Answer: 4
right(0) right(1) right(2) right(3)
Answer: 5
right(0) right(3) left(1) left(2)
Answer: 6
right(0) left(1) left(2) left(3)
Answer: 7
right(0) right(2) right(3) left(1)
Answer: 8
right(0) right(2) left(1) left(3)
SATISFIABLE

Models      : 8
Time        : 0.000
  Prepare   : 0.000
  Prepro.   : 0.000
  Solving   : 0.000

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:

```
D:\SEM1\AI\clingo-3.0.5-win64>clingo pendulum.txt -c maxstep=3 10
Answer: 1
right(0) right(1) right(3) left(2)
Answer: 2
right(0) right(1) left(2) left(3)
Answer: 3
right(0) right(1) right(2) left(3)
Answer: 4
right(0) right(1) right(2) right(3)
Answer: 5
right(0) right(3) left(1) left(2)
Answer: 6
right(0) left(1) left(2) left(3)
Answer: 7
right(0) right(2) right(3) left(1)
Answer: 8
right(0) right(2) left(1) left(3)
SATISFIABLE

Models       : 8
Time         : 0.000
  Prepare    : 0.000
  Prepro.    : 0.000
  Solving    : 0.000

D:\SEM1\AI\clingo-3.0.5-win64>
```

18

Answer: No of valid states = 5145

Lines included in the program:

```
%one block can't be on itself.
:- on(B,B,ST).
%if x is on y, then y can't be on x
:- on(B,B1,ST), on(B1,B,ST).
```

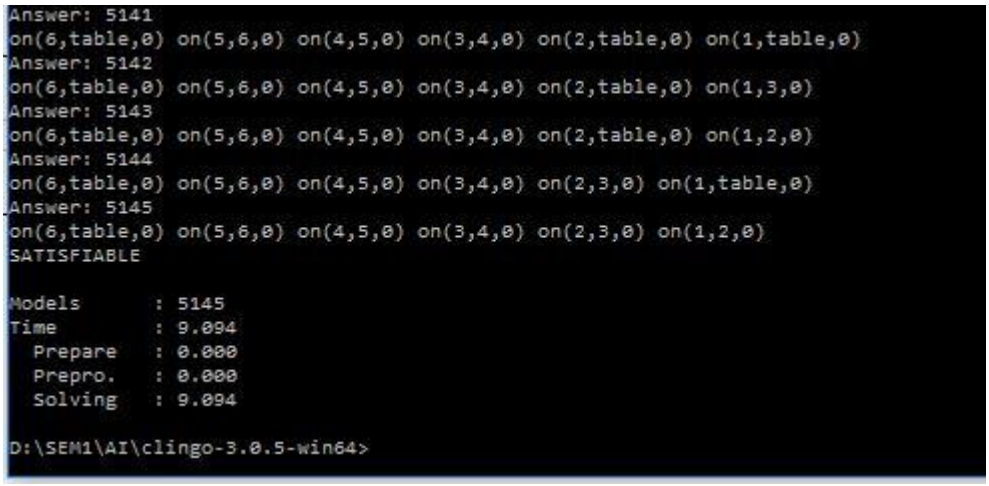
Lines commented:

All the initial and goal conditions were commented out and maxstep is set to 0.

Output:

```
Answer: 5143
on(6,table,0) on(5,6,0) on(4,5,0) on(3,4,0) on(2,table,0) on(1,2,0)
Answer: 5144
on(6,table,0) on(5,6,0) on(4,5,0) on(3,4,0) on(2,3,0) on(1,table,0)
Answer: 5145
on(6,table,0) on(5,6,0) on(4,5,0) on(3,4,0) on(2,3,0) on(1,2,0)
SATISFIABLE
Models       : 5145
Time         : 9.094
  Prepare    : 0.000
  Prepro.    : 0.000
  Solving    : 9.094

D:\SEM1\AI\clingo-3.0.5-win64>
```

Screenshot:



In order to remove cyclic arrangements (if any), there should be a constraint like :-on(B,B1,T), on(B1,B2,T1), on(B2,B, T2). and exempting table from this as any number of blocks can be on the table.

19

Answer: Minimum length = 8 (for 3 grippers)

There wasn't a reduced length for grippers = 4.

For grippers = 2, min length was 9. So 8 is the minimum length.

Lines included in the program:

```
%serialize

#domain block(B2).
#domain location(L2).
:- on(B,B1,ST), move(B2,B1,ST), move(B,L2,ST).

%initial
on(m,table,0). on(l,m,0). on(a,l,0). on(b,a,0). on(c,b,0).
on(o,table,0). on(n,o,0). on(d,n,0). on(e,d,0). on(j,e,0).
on(k,j,0). on(f,table,0). on(g,f,0). on(h,g,0). on(i,h,0).

%goal
:- not on(e,j,maxstep).
:- not on(a,e,maxstep).
:- not on(n,a,maxstep).
:- not on(i,d,maxstep).
:- not on(h,i,maxstep).
:- not on(m,h,maxstep).
:- not on(o,m,maxstep).
:- not on(k,g,maxstep).
:- not on(c,k,maxstep).
:- not on(b,c,maxstep).
:- not on(l,b,maxstep).
```

Output:

D:\SEM1\AI\clingo-3.0.5-win64>clingo blocks1.txt -c maxstep=8 -c grippers=3
Answer: 1
move(o,m,7) move(n,a,7) move(l,b,7) move(n,table,6) move(m,h,6) move(a,e,6) move(l,table,5) move(h,i,5) move(b,c,5) move(n,table,4) move(l,e,4) move(i,d,4) move(l,a,3) move(d,table,3) move(c,k,3) move(k,g,2) move(e,j,2) move(a,table,2) move(j,table,1) move(h,table,1) move(b,table,1) move(k,table,0) move(i,table,0) move(c,table,0)
SATISFIABLE

Models : 1+
Time : 2.422
Prepare : 1.547
Prepro. : 0.828
Solving : 0.047

D:\SEM1\AI\clingo-3.0.5-win64>

Screenshot: