

Project 2: SATPlan and the Tower of Hanoi

CSCI 561

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The *Tower of Hanoi* is a classic puzzle consisting of round disks stacked on pegs. One must move all disks to the final peg, subject to the following constraints:

1. Only one disk can be moved at a time.
2. Each move consists of taking the upper disk from one of the stacks and placing it on top of another stack.
3. No disk may be placed on top of a smaller disk.

Answer the following questions:

1. Create PDDL domains (operators and facts) for the following Tower of Hanoi instances (it is possible that the PDDL operators will be the same):

- (a) Two pegs and one disk.

Operators (all same):

```

1 (define (domain towerofhanoi)
2   (:predicates
3     (clear ?a)
4     (smaller ?a ?b)
5     (on ?a ?b))
6   (:action movedisk :parameters (?disk ?from ?to)
7     :precondition (and (clear ?disk)
8       (smaller ?disk ?to)
9       (on ?disk ?from)
10      (clear ?to))
11     :effect (and (on ?disk ?to)
12       (clear ?from)
13       (not (on ?disk ?from))
14       (not (clear ?to))))

```

Facts:

```

1 (define (problem twopegsonedisk)
2   (:domain towerofhanoi)
3   (:objects peg1 peg2 disk1)
4   (:init (on disk1 peg1)
5     (clear disk1)
6     (clear peg2)
7     (smaller disk1 peg1)
8     (smaller disk1 peg2))
9   (:goal (on disk1 peg2)))

```

- (b) Three pegs and two disks.

Operators (all same):

```

1 (define (domain towerofhanoi)
2   (:predicates
3     (clear ?a)
4     (smaller ?a ?b)
5     (on ?a ?b))
6   (:action movedisk :parameters (?disk ?from ?to)
7     :precondition (and (clear ?disk)
8       (smaller ?disk ?to)
9       (on ?disk ?from)
10      (clear ?to))

```

```

11      :effect (and (on ?disk ?to)
12                  (clear ?from)
13                  (not (on ?disk ?from))
14                  (not (clear ?to))))))

```

Facts:

```

1 (define (problem threepegstwodisks)
2   (:domain towerofhanoi)
3   (:objects peg1 peg2 peg3 disk1 disk2)
4   (:init (on disk2 peg1)
5           (on disk1 disk2)
6           (clear disk1)
7           (clear peg2)
8           (clear peg3)
9           (smaller disk1 disk2)
10          (smaller disk1 peg1)
11          (smaller disk1 peg2)
12          (smaller disk1 peg3)
13          (smaller disk2 peg1)
14          (smaller disk2 peg2)
15          (smaller disk2 peg3))
16   (:goal (and (on disk1 disk2) (on disk2 peg3))))

```

(c) Three pegs and four disks.

Operators (all same):

```

1 (define (domain towerofhanoi)
2   (:predicates
3     (clear ?a)
4     (smaller ?a ?b)
5     (on ?a ?b))
6   (:action movedisk :parameters (?disk ?from ?to)
7     :precondition (and (clear ?disk)
8                        (smaller ?disk ?to)
9                        (on ?disk ?from)
10                       (clear ?to))
11     :effect (and (on ?disk ?to)
12                 (clear ?from)
13                 (not (on ?disk ?from))
14                 (not (clear ?to))))))

```

Facts:

```

1 (define (problem threepegsfourdisks)
2   (:domain towerofhanoi)
3   (:objects peg1 peg2 peg3 disk1 disk2 disk3 disk4)
4   (:init (on disk1 peg1)
5           (on disk2 disk1)
6           (on disk3 disk2)
7           (on disk4 disk3)
8           (clear disk4)
9           (clear peg2)
10          (clear peg3)
11          (smaller disk4 disk3)
12          (smaller disk4 disk2)
13          (smaller disk4 disk1)
14          (smaller disk3 disk2)
15          (smaller disk3 disk1)
16          (smaller disk2 disk1)
17          (smaller disk1 peg1) (smaller disk1 peg2) (smaller disk1 peg3)
18          (smaller disk2 peg1) (smaller disk2 peg2) (smaller disk2 peg3)
19          (smaller disk3 peg1) (smaller disk3 peg2) (smaller disk3 peg3)
20          (smaller disk4 peg1) (smaller disk4 peg2) (smaller disk4 peg3))
21   (:goal (and (on disk4 disk3)
22              (on disk3 disk2)
23              (on disk2 disk1)
24              (on disk1 peg3))))

```

2. Download one or more of the following planners and use them to produce plans for your PDDL domains:

- BlackBox: <https://gitlab.com/HenryKautz/BlackBox/>
- Madagascar: <http://research.ics.aalto.fi/software/sat/madagascar/>
- TMKit: <http://tmkit.dyalab.org/>

What plans are produced by each planner for each instance (one, two, four disks)? All plans in this section generated with BlackBox.

(a) Two Peg, One Disk

```
1 (movedisk disk1 peg1 peg2)
```

(b) Three Peg, Two Disk

```
1 (movedisk disk1 disk2 peg2)
2 (movedisk disk2 peg1 peg3)
3 (movedisk disk1 peg2 disk2)
```

(c) Three Peg, Four Disk

```
1 (movedisk disk4 disk3 peg2)
2 (movedisk disk3 disk2 peg3)
3 (movedisk disk4 peg2 disk3)
4 (movedisk disk2 disk1 peg2)
5 (movedisk disk4 disk3 disk1)
6 (movedisk disk3 peg3 disk2)
7 (movedisk disk4 disk1 disk3)
8 (movedisk disk1 peg1 peg3)
9 (movedisk disk4 disk3 disk1)
10 (movedisk disk3 disk2 peg1)
11 (movedisk disk4 disk1 disk3)
12 (movedisk disk2 peg2 disk1)
13 (movedisk disk4 disk3 peg2)
14 (movedisk disk3 peg1 disk2)
15 (movedisk disk4 peg2 disk3)
```

3. Encode the three-peg, two-disk instance as a Boolean formula using the SATPlan method. Please separately indicate the different parts of your encoding (start state, goal conditions, frame axioms, etc.).

(a) Start State

```
1 clear_disk1-0
2 (not clear_disk2-0)
3 (not clear_peg1-0)
4 clear_peg2-0
5 clear_peg3-0
6 (not on_disk1_disk1-0)
7 on_disk1_disk2-0
8 (not on_disk1_peg1-0)
9 (not on_disk1_peg2-0)
10 (not on_disk1_peg3-0)
11 (not on_disk2_disk1-0)
12 (not on_disk2_disk2-0)
13 on_disk2_peg1-0
14 (not on_disk2_peg2-0)
15 (not on_disk2_peg3-0)
16 (not on_peg1_disk1-0)
17 (not on_peg1_disk2-0)
18 (not on_peg1_peg1-0)
19 (not on_peg1_peg2-0)
20 (not on_peg1_peg3-0)
21 (not on_peg2_disk1-0)
22 (not on_peg2_disk2-0)
23 (not on_peg2_peg1-0)
24 (not on_peg2_peg2-0)
25 (not on_peg2_peg3-0)
26 (not on_peg3_disk1-0)
27 (not on_peg3_disk2-0)
28 (not on_peg3_peg1-0)
29 (not on_peg3_peg2-0)
30 (not on_peg3_peg3-0)
31 (not smaller_disk1_disk1-0)
32 smaller_disk1_disk2-0
33 smaller_disk1_peg1-0
34 smaller_disk1_peg2-0
35 smaller_disk1_peg3-0
36 (not smaller_disk2_disk1-0)
37 (not smaller_disk2_disk2-0)
38 smaller_disk2_peg1-0
39 smaller_disk2_peg2-0
```

```

40 smaller_disk2_peg3-0
41 (not smaller_peg1_disk1-0)
42 (not smaller_peg1_disk2-0)
43 (not smaller_peg1_peg1-0)
44 (not smaller_peg1_peg2-0)
45 (not smaller_peg1_peg3-0)
46 (not smaller_peg2_disk1-0)
47 (not smaller_peg2_disk2-0)
48 (not smaller_peg2_peg1-0)
49 (not smaller_peg2_peg2-0)
50 (not smaller_peg2_peg3-0)
51 (not smaller_peg3_disk1-0)
52 (not smaller_peg3_disk2-0)
53 (not smaller_peg3_peg1-0)
54 (not smaller_peg3_peg2-0)
55 (not smaller_peg3_peg3-0)

```

(b) Goal Conditions

```

1 on_disk1_disk2-4
2 on_disk2_peg3-4

```

(c) Frame Axioms

```

1 (or (:iff clear_disk1-0 clear_disk1-1))
2 (or (:iff clear_disk2-0 clear_disk2-1))
3 (or (:iff clear_peg1-0 clear_peg1-1))
4 (or (:iff clear_peg2-0 clear_peg2-1))
5 (or (:iff clear_peg3-0 clear_peg3-1))
6 (or (:iff on_disk1_disk2-0 on_disk1_disk2-1))
7 (or (:iff on_disk1_peg1-0 on_disk1_peg1-1))
8 (or (:iff on_disk1_peg2-0 on_disk1_peg2-1))
9 (or (:iff on_disk1_peg3-0 on_disk1_peg3-1))
10 (or (:iff on_disk2_disk1-0 on_disk2_disk1-1))
11 (or (:iff on_disk2_peg1-0 on_disk2_peg1-1))
12 (or (:iff on_disk2_peg2-0 on_disk2_peg2-1))
13 (or (:iff on_disk2_peg3-0 on_disk2_peg3-1))
14 (or (:iff smaller_disk1_disk1-0 smaller_disk1_disk1-1))
15 (or (:iff smaller_disk1_disk2-0 smaller_disk1_disk2-1))
16 (or (:iff smaller_disk1_peg1-0 smaller_disk1_peg1-1))
17 (or (:iff smaller_disk1_peg2-0 smaller_disk1_peg2-1))
18 (or (:iff smaller_disk1_peg3-0 smaller_disk1_peg3-1))
19 (or (:iff smaller_disk2_disk1-0 smaller_disk2_disk1-1))
20 (or (:iff smaller_disk2_disk2-0 smaller_disk2_disk2-1))
21 (or (:iff smaller_disk2_peg1-0 smaller_disk2_peg1-1))
22 (or (:iff smaller_disk2_peg2-0 smaller_disk2_peg2-1))
23 (or (:iff smaller_disk2_peg3-0 smaller_disk2_peg3-1))
24 (or (:iff smaller_peg1_disk1-0 smaller_peg1_disk1-1))
25 (or (:iff smaller_peg1_disk2-0 smaller_peg1_disk2-1))
26 (or (:iff smaller_peg1_peg1-0 smaller_peg1_peg1-1))
27 (or (:iff smaller_peg1_peg2-0 smaller_peg1_peg2-1))
28 (or (:iff smaller_peg1_peg3-0 smaller_peg1_peg3-1))
29 (or (:iff smaller_peg2_disk1-0 smaller_peg2_disk1-1))
30 (or (:iff smaller_peg2_disk2-0 smaller_peg2_disk2-1))
31 (or (:iff smaller_peg2_peg1-0 smaller_peg2_peg1-1))
32 (or (:iff smaller_peg2_peg2-0 smaller_peg2_peg2-1))
33 (or (:iff smaller_peg2_peg3-0 smaller_peg2_peg3-1))
34 (or (:iff smaller_peg3_disk1-0 smaller_peg3_disk1-1))
35 (or (:iff smaller_peg3_disk2-0 smaller_peg3_disk2-1))
36 (or (:iff smaller_peg3_peg1-0 smaller_peg3_peg1-1))
37 (or (:iff smaller_peg3_peg2-0 smaller_peg3_peg2-1))
38 (or (:iff smaller_peg3_peg3-0 smaller_peg3_peg3-1))
39 (or (:iff clear_disk1-1 clear_disk1-2) movedisk_disk2_disk1_peg1-1
    movedisk_disk2_disk1_peg2-1 movedisk_disk2_disk1_peg3-1 movedisk_disk2_peg1_disk1-1
    movedisk_disk2_peg2_disk1-1 movedisk_disk2_peg3_disk1-1))
40 (or (:iff clear_disk2-1 clear_disk2-2) movedisk_disk1_disk2_peg1-1
    movedisk_disk1_disk2_peg2-1 movedisk_disk1_disk2_peg3-1 movedisk_disk1_peg1_disk2-1
    movedisk_disk1_peg2_disk2-1 movedisk_disk1_peg3_disk2-1))
41 (or (:iff clear_peg1-1 clear_peg1-2) movedisk_disk1_disk2_peg1-1
    movedisk_disk1_peg1_disk2-1 movedisk_disk1_peg1_peg2-1 movedisk_disk1_peg1_peg3-1
    movedisk_disk1_peg2_peg1-1 movedisk_disk1_peg3_peg1-1 movedisk_disk2_disk1_peg1-1
    movedisk_disk2_peg1_disk1-1 movedisk_disk2_peg1_peg2-1 movedisk_disk2_peg1_peg3-1
    movedisk_disk2_peg2_peg1-1 movedisk_disk2_peg3_peg1-1))
42 (or (:iff clear_peg2-1 clear_peg2-2) movedisk_disk1_disk2_peg2-1
    movedisk_disk1_peg1_peg2-1 movedisk_disk1_peg2_disk2-1 movedisk_disk1_peg2_peg1-1
    movedisk_disk1_peg2_peg3-1 movedisk_disk1_peg3_peg2-1 movedisk_disk2_disk1_peg2-1
    movedisk_disk2_peg1_peg2-1 movedisk_disk2_peg2_disk1-1 movedisk_disk2_peg2_peg1-1
    movedisk_disk2_peg2_peg3-1 movedisk_disk2_peg3_peg2-1))
43 (or (:iff clear_peg3-1 clear_peg3-2) movedisk_disk1_disk2_peg3-1
    movedisk_disk1_peg1_peg3-1 movedisk_disk1_peg2_peg3-1 movedisk_disk1_peg3_disk2-1

```

```

movedisk_disk1_peg3_peg1-1 movedisk_disk1_peg3_peg2-1 movedisk_disk2_disk1_peg3-1
movedisk_disk2_peg1_peg3-1 movedisk_disk2_peg2_peg3-1 movedisk_disk2_peg3_disk1-1
movedisk_disk2_peg3_peg1-1 movedisk_disk2_peg3_peg2-1)
44 (or (: iff on_disk1_disk2-1 on_disk1_disk2-2) movedisk_disk1_disk2_peg1-1
movedisk_disk1_disk2_peg2-1 movedisk_disk1_disk2_peg3-1 movedisk_disk1_peg1_disk2-1
movedisk_disk1_peg2_disk2-1 movedisk_disk1_peg3_disk2-1)
45 (or (: iff on_disk1_peg1-1 on_disk1_peg1-2) movedisk_disk1_disk2_peg1-1
movedisk_disk1_peg1_disk2-1 movedisk_disk1_peg1_peg2-1 movedisk_disk1_peg1_peg3-1
movedisk_disk1_peg2_peg1-1 movedisk_disk1_peg3_peg1-1)
46 (or (: iff on_disk1_peg2-1 on_disk1_peg2-2) movedisk_disk1_disk2_peg2-1
movedisk_disk1_peg1_peg2-1 movedisk_disk1_peg2_disk2-1 movedisk_disk1_peg2_peg1-1
movedisk_disk1_peg2_peg3-1 movedisk_disk1_peg3_peg2-1)
47 (or (: iff on_disk1_peg3-1 on_disk1_peg3-2) movedisk_disk1_disk2_peg3-1
movedisk_disk1_peg1_peg3-1 movedisk_disk1_peg2_peg3-1 movedisk_disk1_peg3_disk2-1
movedisk_disk1_peg3_peg1-1 movedisk_disk1_peg3_peg2-1)
48 (or (: iff on_disk2_disk1-1 on_disk2_disk1-2) movedisk_disk2_disk1_peg1-1
movedisk_disk2_disk1_peg2-1 movedisk_disk2_disk1_peg3-1 movedisk_disk2_peg1_disk1-1
movedisk_disk2_peg2_disk1-1 movedisk_disk2_peg3_disk1-1)
49 (or (: iff on_disk2_peg1-1 on_disk2_peg1-2) movedisk_disk2_disk1_peg1-1
movedisk_disk2_peg1_disk1-1 movedisk_disk2_peg1_peg2-1 movedisk_disk2_peg1_peg3-1
movedisk_disk2_peg2_peg1-1 movedisk_disk2_peg3_peg1-1)
50 (or (: iff on_disk2_peg2-1 on_disk2_peg2-2) movedisk_disk2_disk1_peg2-1
movedisk_disk2_peg1_peg2-1 movedisk_disk2_peg2_disk1-1 movedisk_disk2_peg2_peg1-1
movedisk_disk2_peg2_peg3-1 movedisk_disk2_peg3_peg2-1)
51 (or (: iff on_disk2_peg3-1 on_disk2_peg3-2) movedisk_disk2_disk1_peg3-1
movedisk_disk2_peg1_peg3-1 movedisk_disk2_peg2_peg3-1 movedisk_disk2_peg3_disk1-1
movedisk_disk2_peg3_peg1-1 movedisk_disk2_peg3_peg2-1)
52 (or (: iff smaller_disk1_disk1-1 smaller_disk1_disk1-2))
53 (or (: iff smaller_disk1_disk2-1 smaller_disk1_disk2-2))
54 (or (: iff smaller_disk1_peg1-1 smaller_disk1_peg1-2))
55 (or (: iff smaller_disk1_peg2-1 smaller_disk1_peg2-2))
56 (or (: iff smaller_disk1_peg3-1 smaller_disk1_peg3-2))
57 (or (: iff smaller_disk2_disk1-1 smaller_disk2_disk1-2))
58 (or (: iff smaller_disk2_disk2-1 smaller_disk2_disk2-2))
59 (or (: iff smaller_disk2_peg1-1 smaller_disk2_peg1-2))
60 (or (: iff smaller_disk2_peg2-1 smaller_disk2_peg2-2))
61 (or (: iff smaller_disk2_peg3-1 smaller_disk2_peg3-2))
62 (or (: iff smaller_peg1_disk1-1 smaller_peg1_disk1-2))
63 (or (: iff smaller_peg1_disk2-1 smaller_peg1_disk2-2))
64 (or (: iff smaller_peg1_peg1-1 smaller_peg1_peg1-2))
65 (or (: iff smaller_peg1_peg2-1 smaller_peg1_peg2-2))
66 (or (: iff smaller_peg1_peg3-1 smaller_peg1_peg3-2))
67 (or (: iff smaller_peg2_disk1-1 smaller_peg2_disk1-2))
68 (or (: iff smaller_peg2_disk2-1 smaller_peg2_disk2-2))
69 (or (: iff smaller_peg2_peg1-1 smaller_peg2_peg1-2))
70 (or (: iff smaller_peg2_peg2-1 smaller_peg2_peg2-2))
71 (or (: iff smaller_peg2_peg3-1 smaller_peg2_peg3-2))
72 (or (: iff smaller_peg3_disk1-1 smaller_peg3_disk1-2))
73 (or (: iff smaller_peg3_disk2-1 smaller_peg3_disk2-2))
74 (or (: iff smaller_peg3_peg1-1 smaller_peg3_peg1-2))
75 (or (: iff smaller_peg3_peg2-1 smaller_peg3_peg2-2))
76 (or (: iff smaller_peg3_peg3-1 smaller_peg3_peg3-2))
77 (or (: iff clear_disk1-2 clear_disk1-3) movedisk_disk2_disk1_peg1-2
movedisk_disk2_disk1_peg2-2 movedisk_disk2_disk1_peg3-2 movedisk_disk2_peg1_disk1-2
movedisk_disk2_peg2_disk1-2 movedisk_disk2_peg3_disk1-2)
78 (or (: iff clear_disk2-2 clear_disk2-3) movedisk_disk1_disk2_peg1-2
movedisk_disk1_disk2_peg2-2 movedisk_disk1_disk2_peg3-2 movedisk_disk1_peg1_disk2-2
movedisk_disk1_peg2_disk2-2 movedisk_disk1_peg3_disk2-2)
79 (or (: iff clear_peg1-2 clear_peg1-3) movedisk_disk1_disk2_peg1-2
movedisk_disk1_peg1_disk2-2 movedisk_disk1_peg1_peg2-2 movedisk_disk1_peg1_peg3-2
movedisk_disk1_peg2_peg1-2 movedisk_disk1_peg3_peg1-2 movedisk_disk2_disk1_peg1-2
movedisk_disk2_peg1_disk1-2 movedisk_disk2_peg1_peg2-2 movedisk_disk2_peg1_peg3-2
movedisk_disk2_peg2_peg1-2 movedisk_disk2_peg3_peg1-2)
80 (or (: iff clear_peg2-2 clear_peg2-3) movedisk_disk1_disk2_peg2-2
movedisk_disk1_peg1_peg2-2 movedisk_disk1_peg2_disk2-2 movedisk_disk1_peg2_peg1-2
movedisk_disk1_peg2_peg3-2 movedisk_disk1_peg3_peg2-2 movedisk_disk2_disk1_peg2-2
movedisk_disk2_peg1_peg2-2 movedisk_disk2_peg2_disk1-2 movedisk_disk2_peg2_peg1-2
movedisk_disk2_peg2_peg3-2 movedisk_disk2_peg3_peg2-2)
81 (or (: iff clear_peg3-2 clear_peg3-3) movedisk_disk1_disk2_peg3-2
movedisk_disk1_peg1_peg3-2 movedisk_disk1_peg2_peg3-2 movedisk_disk1_peg3_disk2-2
movedisk_disk1_peg3_peg1-2 movedisk_disk1_peg3_peg2-2 movedisk_disk2_disk1_peg3-2
movedisk_disk2_peg1_peg3-2 movedisk_disk2_peg2_peg3-2 movedisk_disk2_peg3_disk1-2
movedisk_disk2_peg3_peg1-2 movedisk_disk2_peg3_peg2-2)
82 (or (: iff on_disk1_disk2-2 on_disk1_disk2-3) movedisk_disk1_disk2_peg1-2
movedisk_disk1_disk2_peg2-2 movedisk_disk1_disk2_peg3-2 movedisk_disk1_peg1_disk2-2
movedisk_disk1_peg2_disk2-2 movedisk_disk1_peg3_disk2-2)
83 (or (: iff on_disk1_peg1-2 on_disk1_peg1-3) movedisk_disk1_disk2_peg1-2
movedisk_disk1_peg1_disk2-2 movedisk_disk1_peg1_peg2-2 movedisk_disk1_peg1_peg3-2
movedisk_disk1_peg2_peg1-2 movedisk_disk1_peg3_peg1-2)
84 (or (: iff on_disk1_peg2-2 on_disk1_peg2-3) movedisk_disk1_disk2_peg2-2
movedisk_disk1_peg1_peg2-2 movedisk_disk1_peg2_disk2-2 movedisk_disk1_peg2_peg1-2

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movedisk_disk1_peg2_peg3-2 movedisk_disk1_peg3_peg2-2)
85 (or (:iff on_disk1_peg3-2 on_disk1_peg3-3) movedisk_disk1_disk2_peg3-2
movedisk_disk1_peg1_peg3-2 movedisk_disk1_peg2_peg3-2 movedisk_disk1_peg3_disk2-2
movedisk_disk1_peg3_peg1-2 movedisk_disk1_peg3_peg2-2)
86 (or (:iff on_disk2_disk1-2 on_disk2_disk1-3) movedisk_disk2_disk1_peg1-2
movedisk_disk2_disk1_peg2-2 movedisk_disk2_disk1_peg3-2 movedisk_disk2_peg1_disk1-2
movedisk_disk2_peg2_disk1-2 movedisk_disk2_peg3_disk1-2)
87 (or (:iff on_disk2_peg1-2 on_disk2_peg1-3) movedisk_disk2_disk1_peg1-2
movedisk_disk2_peg1_disk1-2 movedisk_disk2_peg1_peg2-2 movedisk_disk2_peg1_peg3-2
movedisk_disk2_peg2_peg1-2 movedisk_disk2_peg3_peg1-2)
88 (or (:iff on_disk2_peg2-2 on_disk2_peg2-3) movedisk_disk2_disk1_peg2-2
movedisk_disk2_peg1_peg2-2 movedisk_disk2_peg2_disk1-2 movedisk_disk2_peg2_peg1-2
movedisk_disk2_peg2_peg3-2 movedisk_disk2_peg3_peg2-2)
89 (or (:iff on_disk2_peg3-2 on_disk2_peg3-3) movedisk_disk2_disk1_peg3-2
movedisk_disk2_peg1_peg3-2 movedisk_disk2_peg2_peg3-2 movedisk_disk2_peg3_disk1-2
movedisk_disk2_peg3_peg1-2 movedisk_disk2_peg3_peg2-2)
90 (or (:iff smaller_disk1_disk1-2 smaller_disk1_disk1-3))
91 (or (:iff smaller_disk1_disk2-2 smaller_disk1_disk2-3))
92 (or (:iff smaller_disk1_peg1-2 smaller_disk1_peg1-3))
93 (or (:iff smaller_disk1_peg2-2 smaller_disk1_peg2-3))
94 (or (:iff smaller_disk1_peg3-2 smaller_disk1_peg3-3))
95 (or (:iff smaller_disk2_disk1-2 smaller_disk2_disk1-3))
96 (or (:iff smaller_disk2_disk2-2 smaller_disk2_disk2-3))
97 (or (:iff smaller_disk2_peg1-2 smaller_disk2_peg1-3))
98 (or (:iff smaller_disk2_peg2-2 smaller_disk2_peg2-3))
99 (or (:iff smaller_disk2_peg3-2 smaller_disk2_peg3-3))
100 (or (:iff smaller_peg1_disk1-2 smaller_peg1_disk1-3))
101 (or (:iff smaller_peg1_disk2-2 smaller_peg1_disk2-3))
102 (or (:iff smaller_peg1_peg1-2 smaller_peg1_peg1-3))
103 (or (:iff smaller_peg1_peg2-2 smaller_peg1_peg2-3))
104 (or (:iff smaller_peg1_peg3-2 smaller_peg1_peg3-3))
105 (or (:iff smaller_peg2_disk1-2 smaller_peg2_disk1-3))
106 (or (:iff smaller_peg2_disk2-2 smaller_peg2_disk2-3))
107 (or (:iff smaller_peg2_peg1-2 smaller_peg2_peg1-3))
108 (or (:iff smaller_peg2_peg2-2 smaller_peg2_peg2-3))
109 (or (:iff smaller_peg2_peg3-2 smaller_peg2_peg3-3))
110 (or (:iff smaller_peg3_disk1-2 smaller_peg3_disk1-3))
111 (or (:iff smaller_peg3_disk2-2 smaller_peg3_disk2-3))
112 (or (:iff smaller_peg3_peg1-2 smaller_peg3_peg1-3))
113 (or (:iff smaller_peg3_peg2-2 smaller_peg3_peg2-3))
114 (or (:iff smaller_peg3_peg3-2 smaller_peg3_peg3-3))
115 (or (:iff clear_disk1-3 clear_disk1-4) movedisk_disk2_disk1_peg1-3
movedisk_disk2_disk1_peg2-3 movedisk_disk2_disk1_peg3-3 movedisk_disk2_peg1_disk1-3
movedisk_disk2_peg2_disk1-3 movedisk_disk2_peg3_disk1-3)
116 (or (:iff clear_disk2-3 clear_disk2-4) movedisk_disk1_disk2_peg1-3
movedisk_disk1_disk2_peg2-3 movedisk_disk1_disk2_peg3-3 movedisk_disk1_peg1_disk2-3
movedisk_disk1_peg2_disk2-3 movedisk_disk1_peg3_disk2-3)
117 (or (:iff clear_peg1-3 clear_peg1-4) movedisk_disk1_disk2_peg1-3
movedisk_disk1_peg1_disk2-3 movedisk_disk1_peg1_peg2-3 movedisk_disk1_peg1_peg3-3
movedisk_disk1_peg2_peg1-3 movedisk_disk1_peg3_peg1-3 movedisk_disk2_disk1_peg1-3
movedisk_disk2_peg1_disk1-3 movedisk_disk2_peg1_peg2-3 movedisk_disk2_peg1_peg3-3
movedisk_disk2_peg2_peg1-3 movedisk_disk2_peg3_peg1-3)
118 (or (:iff clear_peg2-3 clear_peg2-4) movedisk_disk1_disk2_peg2-3
movedisk_disk1_peg1_peg2-3 movedisk_disk1_peg2_disk2-3 movedisk_disk1_peg2_peg1-3
movedisk_disk1_peg2_peg3-3 movedisk_disk1_peg3_peg2-3 movedisk_disk2_disk1_peg2-3
movedisk_disk2_peg1_peg2-3 movedisk_disk2_peg2_disk1-3 movedisk_disk2_peg2_peg1-3
movedisk_disk2_peg2_peg3-3 movedisk_disk2_peg3_peg2-3)
119 (or (:iff clear_peg3-3 clear_peg3-4) movedisk_disk1_disk2_peg3-3
movedisk_disk1_peg1_peg3-3 movedisk_disk1_peg2_peg3-3 movedisk_disk1_peg3_disk2-3
movedisk_disk1_peg3_peg1-3 movedisk_disk1_peg3_peg2-3 movedisk_disk2_disk1_peg3-3
movedisk_disk2_peg1_peg3-3 movedisk_disk2_peg2_peg3-3 movedisk_disk2_peg3_disk1-3
movedisk_disk2_peg3_peg1-3 movedisk_disk2_peg3_peg2-3)
120 (or (:iff on_disk1_disk2-3 on_disk1_disk2-4) movedisk_disk1_disk2_peg1-3
movedisk_disk1_disk2_peg2-3 movedisk_disk1_disk2_peg3-3 movedisk_disk1_peg1_disk2-3
movedisk_disk1_peg2_disk2-3 movedisk_disk1_peg3_disk2-3)
121 (or (:iff on_disk1_peg1-3 on_disk1_peg1-4) movedisk_disk1_disk2_peg1-3
movedisk_disk1_peg1_disk2-3 movedisk_disk1_peg1_peg2-3 movedisk_disk1_peg1_peg3-3
movedisk_disk1_peg2_peg1-3 movedisk_disk1_peg3_peg1-3)
122 (or (:iff on_disk1_peg2-3 on_disk1_peg2-4) movedisk_disk1_disk2_peg2-3
movedisk_disk1_peg1_peg2-3 movedisk_disk1_peg2_disk2-3 movedisk_disk1_peg2_peg1-3
movedisk_disk1_peg2_peg3-3 movedisk_disk1_peg3_peg2-3)
123 (or (:iff on_disk1_peg3-3 on_disk1_peg3-4) movedisk_disk1_disk2_peg3-3
movedisk_disk1_peg1_peg3-3 movedisk_disk1_peg2_peg3-3 movedisk_disk1_peg3_disk2-3
movedisk_disk1_peg3_peg1-3 movedisk_disk1_peg3_peg2-3)
124 (or (:iff on_disk2_disk1-3 on_disk2_disk1-4) movedisk_disk2_disk1_peg1-3
movedisk_disk2_disk1_peg2-3 movedisk_disk2_disk1_peg3-3 movedisk_disk2_peg1_disk1-3
movedisk_disk2_peg2_disk1-3 movedisk_disk2_peg3_disk1-3)
125 (or (:iff on_disk2_peg1-3 on_disk2_peg1-4) movedisk_disk2_disk1_peg1-3
movedisk_disk2_peg1_disk1-3 movedisk_disk2_peg1_peg2-3 movedisk_disk2_peg1_peg3-3
movedisk_disk2_peg2_peg1-3 movedisk_disk2_peg3_peg1-3)
126 (or (:iff on_disk2_peg2-3 on_disk2_peg2-4) movedisk_disk2_disk1_peg2-3

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movedisk_disk2_peg1_peg2-3 movedisk_disk2_peg2_disk1-3 movedisk_disk2_peg2_peg1-3
movedisk_disk2_peg2_peg3-3 movedisk_disk2_peg3_peg2-3)
127 (or (: iff on_disk2_peg3-3 on_disk2_peg3-4) movedisk_disk2_disk1_peg3-3
movedisk_disk2_peg1_peg3-3 movedisk_disk2_peg2_peg3-3 movedisk_disk2_peg3_disk1-3
movedisk_disk2_peg3_peg1-3 movedisk_disk2_peg3_peg2-3)
128 (or (: iff smaller_disk1_disk1-3 smaller_disk1_disk1-4))
129 (or (: iff smaller_disk1_disk2-3 smaller_disk1_disk2-4))
130 (or (: iff smaller_disk1_peg1-3 smaller_disk1_peg1-4))
131 (or (: iff smaller_disk1_peg2-3 smaller_disk1_peg2-4))
132 (or (: iff smaller_disk1_peg3-3 smaller_disk1_peg3-4))
133 (or (: iff smaller_disk2_disk1-3 smaller_disk2_disk1-4))
134 (or (: iff smaller_disk2_disk2-3 smaller_disk2_disk2-4))
135 (or (: iff smaller_disk2_peg1-3 smaller_disk2_peg1-4))
136 (or (: iff smaller_disk2_peg2-3 smaller_disk2_peg2-4))
137 (or (: iff smaller_disk2_peg3-3 smaller_disk2_peg3-4))
138 (or (: iff smaller_peg1_disk1-3 smaller_peg1_disk1-4))
139 (or (: iff smaller_peg1_disk2-3 smaller_peg1_disk2-4))
140 (or (: iff smaller_peg1_peg1-3 smaller_peg1_peg1-4))
141 (or (: iff smaller_peg1_peg2-3 smaller_peg1_peg2-4))
142 (or (: iff smaller_peg1_peg3-3 smaller_peg1_peg3-4))
143 (or (: iff smaller_peg2_disk1-3 smaller_peg2_disk1-4))
144 (or (: iff smaller_peg2_disk2-3 smaller_peg2_disk2-4))
145 (or (: iff smaller_peg2_peg1-3 smaller_peg2_peg1-4))
146 (or (: iff smaller_peg2_peg2-3 smaller_peg2_peg2-4))
147 (or (: iff smaller_peg2_peg3-3 smaller_peg2_peg3-4))
148 (or (: iff smaller_peg3_disk1-3 smaller_peg3_disk1-4))
149 (or (: iff smaller_peg3_disk2-3 smaller_peg3_disk2-4))
150 (or (: iff smaller_peg3_peg1-3 smaller_peg3_peg1-4))
151 (or (: iff smaller_peg3_peg2-3 smaller_peg3_peg2-4))
152 (or (: iff smaller_peg3_peg3-3 smaller_peg3_peg3-4))

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(d) Operator Encoding

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1 (:implies movedisk_disk1_disk2_peg1-1 (and clear_disk1-1 smaller_disk1_peg1-1
on_disk1_disk2-1 clear_peg1-1 on_disk1_peg1-2 clear_disk2-2 (not on_disk1_disk2-2) (
not clear_peg1-2)))
2 (:implies movedisk_disk1_disk2_peg2-1 (and clear_disk1-1 smaller_disk1_peg2-1
on_disk1_disk2-1 clear_peg2-1 on_disk1_peg2-2 clear_disk2-2 (not on_disk1_disk2-2) (
not clear_peg2-2)))
3 (:implies movedisk_disk1_disk2_peg3-1 (and clear_disk1-1 smaller_disk1_peg3-1
on_disk1_disk2-1 clear_peg3-1 on_disk1_peg3-2 clear_disk2-2 (not on_disk1_disk2-2) (
not clear_peg3-2)))
4 (:implies movedisk_disk1_peg1_disk2-1 (and clear_disk1-1 smaller_disk1_disk2-1
on_disk1_peg1-1 clear_disk2-1 on_disk1_disk2-2 clear_peg1-2 (not on_disk1_peg1-2) (
not clear_disk2-2)))
5 (:implies movedisk_disk1_peg1_peg2-1 (and clear_disk1-1 smaller_disk1_peg2-1
on_disk1_peg1-1 clear_peg2-1 on_disk1_peg2-2 clear_peg1-2 (not on_disk1_peg1-2) (not
clear_peg2-2)))
6 (:implies movedisk_disk1_peg1_peg3-1 (and clear_disk1-1 smaller_disk1_peg3-1
on_disk1_peg1-1 clear_peg3-1 on_disk1_peg3-2 clear_peg1-2 (not on_disk1_peg1-2) (not
clear_peg3-2)))
7 (:implies movedisk_disk1_peg2_disk2-1 (and clear_disk1-1 smaller_disk1_disk2-1
on_disk1_peg2-1 clear_disk2-1 on_disk1_disk2-2 clear_peg2-2 (not on_disk1_peg2-2) (
not clear_disk2-2)))
8 (:implies movedisk_disk1_peg2_peg1-1 (and clear_disk1-1 smaller_disk1_peg1-1
on_disk1_peg2-1 clear_peg1-1 on_disk1_peg1-2 clear_peg2-2 (not on_disk1_peg2-2) (not
clear_peg1-2)))
9 (:implies movedisk_disk1_peg2_peg3-1 (and clear_disk1-1 smaller_disk1_peg3-1
on_disk1_peg2-1 clear_peg3-1 on_disk1_peg3-2 clear_peg2-2 (not on_disk1_peg2-2) (not
clear_peg3-2)))
10 (:implies movedisk_disk1_peg3_disk2-1 (and clear_disk1-1 smaller_disk1_disk2-1
on_disk1_peg3-1 clear_disk2-1 on_disk1_disk2-2 clear_peg3-2 (not on_disk1_peg3-2) (
not clear_disk2-2)))
11 (:implies movedisk_disk1_peg3_peg1-1 (and clear_disk1-1 smaller_disk1_peg1-1
on_disk1_peg3-1 clear_peg1-1 on_disk1_peg1-2 clear_peg3-2 (not on_disk1_peg3-2) (not
clear_peg1-2)))
12 (:implies movedisk_disk1_peg3_peg2-1 (and clear_disk1-1 smaller_disk1_peg2-1
on_disk1_peg3-1 clear_peg2-1 on_disk1_peg2-2 clear_peg3-2 (not on_disk1_peg3-2) (not
clear_peg2-2)))
13 (:implies movedisk_disk2_disk1_peg1-1 (and clear_disk2-1 smaller_disk2_peg1-1
on_disk2_disk1-1 clear_peg1-1 on_disk2_peg1-2 clear_disk1-2 (not on_disk2_disk1-2) (
not clear_peg1-2)))
14 (:implies movedisk_disk2_disk1_peg2-1 (and clear_disk2-1 smaller_disk2_peg2-1
on_disk2_disk1-1 clear_peg2-1 on_disk2_peg2-2 clear_disk1-2 (not on_disk2_disk1-2) (
not clear_peg2-2)))
15 (:implies movedisk_disk2_disk1_peg3-1 (and clear_disk2-1 smaller_disk2_peg3-1
on_disk2_disk1-1 clear_peg3-1 on_disk2_peg3-2 clear_disk1-2 (not on_disk2_disk1-2) (
not clear_peg3-2)))
16 (:implies movedisk_disk2_peg1_disk1-1 (and clear_disk2-1 smaller_disk2_disk1-1
on_disk2_peg1-1 clear_disk1-1 on_disk2_disk1-2 clear_peg1-2 (not on_disk2_peg1-2) (
not clear_disk1-2)))

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17 (:implies movedisk_disk2_peg1_peg2-1 (and clear_disk2-1 smaller_disk2_peg2-1
    on_disk2_peg1-1 clear_peg2-1 on_disk2_peg2-2 clear_peg1-2 (not on_disk2_peg1-2) (not
    clear_peg2-2)))
18 (:implies movedisk_disk2_peg1_peg3-1 (and clear_disk2-1 smaller_disk2_peg3-1
    on_disk2_peg1-1 clear_peg3-1 on_disk2_peg3-2 clear_peg1-2 (not on_disk2_peg1-2) (not
    clear_peg3-2)))
19 (:implies movedisk_disk2_peg2_disk1-1 (and clear_disk2-1 smaller_disk2_disk1-1
    on_disk2_peg2-1 clear_disk1-1 on_disk2_disk1-2 clear_peg2-2 (not on_disk2_peg2-2) (
    not clear_disk1-2)))
20 (:implies movedisk_disk2_peg2_peg1-1 (and clear_disk2-1 smaller_disk2_peg1-1
    on_disk2_peg2-1 clear_peg1-1 on_disk2_peg1-2 clear_peg2-2 (not on_disk2_peg2-2) (not
    clear_peg1-2)))
21 (:implies movedisk_disk2_peg2_peg3-1 (and clear_disk2-1 smaller_disk2_peg3-1
    on_disk2_peg2-1 clear_peg3-1 on_disk2_peg3-2 clear_peg2-2 (not on_disk2_peg2-2) (not
    clear_peg3-2)))
22 (:implies movedisk_disk2_peg3_disk1-1 (and clear_disk2-1 smaller_disk2_disk1-1
    on_disk2_peg3-1 clear_disk1-1 on_disk2_disk1-2 clear_peg3-2 (not on_disk2_peg3-2) (
    not clear_disk1-2)))
23 (:implies movedisk_disk2_peg3_peg1-1 (and clear_disk2-1 smaller_disk2_peg1-1
    on_disk2_peg3-1 clear_peg1-1 on_disk2_peg1-2 clear_peg3-2 (not on_disk2_peg3-2) (not
    clear_peg1-2)))
24 (:implies movedisk_disk2_peg3_peg2-1 (and clear_disk2-1 smaller_disk2_peg2-1
    on_disk2_peg3-1 clear_peg2-1 on_disk2_peg2-2 clear_peg3-2 (not on_disk2_peg3-2) (not
    clear_peg2-2)))
25 (:implies movedisk_disk1_disk2_peg1-2 (and clear_disk1-2 smaller_disk1_peg1-2
    on_disk1_disk2-2 clear_peg1-2 on_disk1_peg1-3 clear_disk2-3 (not on_disk1_disk2-3) (
    not clear_peg1-3)))
26 (:implies movedisk_disk1_disk2_peg2-2 (and clear_disk1-2 smaller_disk1_peg2-2
    on_disk1_disk2-2 clear_peg2-2 on_disk1_peg2-3 clear_disk2-3 (not on_disk1_disk2-3) (
    not clear_peg2-3)))
27 (:implies movedisk_disk1_disk2_peg3-2 (and clear_disk1-2 smaller_disk1_peg3-2
    on_disk1_disk2-2 clear_peg3-2 on_disk1_peg3-3 clear_disk2-3 (not on_disk1_disk2-3) (
    not clear_peg3-3)))
28 (:implies movedisk_disk1_peg1_disk2-2 (and clear_disk1-2 smaller_disk1_disk2-2
    on_disk1_peg1-2 clear_disk2-2 on_disk1_disk2-3 clear_peg1-3 (not on_disk1_peg1-3) (
    not clear_disk2-3)))
29 (:implies movedisk_disk1_peg1_peg2-2 (and clear_disk1-2 smaller_disk1_peg2-2
    on_disk1_peg1-2 clear_peg2-2 on_disk1_peg2-3 clear_peg1-3 (not on_disk1_peg1-3) (not
    clear_peg2-3)))
30 (:implies movedisk_disk1_peg1_peg3-2 (and clear_disk1-2 smaller_disk1_peg3-2
    on_disk1_peg1-2 clear_peg3-2 on_disk1_peg3-3 clear_peg1-3 (not on_disk1_peg1-3) (not
    clear_peg3-3)))
31 (:implies movedisk_disk1_peg2_disk2-2 (and clear_disk1-2 smaller_disk1_disk2-2
    on_disk1_peg2-2 clear_disk2-2 on_disk1_disk2-3 clear_peg2-3 (not on_disk1_peg2-3) (
    not clear_disk2-3)))
32 (:implies movedisk_disk1_peg2_peg1-2 (and clear_disk1-2 smaller_disk1_peg1-2
    on_disk1_peg2-2 clear_peg1-2 on_disk1_peg1-3 clear_peg2-3 (not on_disk1_peg2-3) (not
    clear_peg1-3)))
33 (:implies movedisk_disk1_peg2_peg3-2 (and clear_disk1-2 smaller_disk1_peg3-2
    on_disk1_peg2-2 clear_peg3-2 on_disk1_peg3-3 clear_peg2-3 (not on_disk1_peg2-3) (not
    clear_peg3-3)))
34 (:implies movedisk_disk1_peg3_disk2-2 (and clear_disk1-2 smaller_disk1_disk2-2
    on_disk1_peg3-2 clear_disk2-2 on_disk1_disk2-3 clear_peg3-3 (not on_disk1_peg3-3) (
    not clear_disk2-3)))
35 (:implies movedisk_disk1_peg3_peg1-2 (and clear_disk1-2 smaller_disk1_peg1-2
    on_disk1_peg3-2 clear_peg1-2 on_disk1_peg1-3 clear_peg3-3 (not on_disk1_peg3-3) (not
    clear_peg1-3)))
36 (:implies movedisk_disk1_peg3_peg2-2 (and clear_disk1-2 smaller_disk1_peg2-2
    on_disk1_peg3-2 clear_peg2-2 on_disk1_peg2-3 clear_peg3-3 (not on_disk1_peg3-3) (not
    clear_peg2-3)))
37 (:implies movedisk_disk2_disk1_peg1-2 (and clear_disk2-2 smaller_disk2_peg1-2
    on_disk2_disk1-2 clear_peg1-2 on_disk2_peg1-3 clear_disk1-3 (not on_disk2_disk1-3) (
    not clear_peg1-3)))
38 (:implies movedisk_disk2_disk1_peg2-2 (and clear_disk2-2 smaller_disk2_peg2-2
    on_disk2_disk1-2 clear_peg2-2 on_disk2_peg2-3 clear_disk1-3 (not on_disk2_disk1-3) (
    not clear_peg2-3)))
39 (:implies movedisk_disk2_disk1_peg3-2 (and clear_disk2-2 smaller_disk2_peg3-2
    on_disk2_disk1-2 clear_peg3-2 on_disk2_peg3-3 clear_disk1-3 (not on_disk2_disk1-3) (
    not clear_peg3-3)))
40 (:implies movedisk_disk2_peg1_disk1-2 (and clear_disk2-2 smaller_disk2_disk1-2
    on_disk2_peg1-2 clear_disk1-2 on_disk2_disk1-3 clear_peg1-3 (not on_disk2_peg1-3) (
    not clear_disk1-3)))
41 (:implies movedisk_disk2_peg1_peg2-2 (and clear_disk2-2 smaller_disk2_peg2-2
    on_disk2_peg1-2 clear_peg2-2 on_disk2_peg2-3 clear_peg1-3 (not on_disk2_peg1-3) (not
    clear_peg2-3)))
42 (:implies movedisk_disk2_peg1_peg3-2 (and clear_disk2-2 smaller_disk2_peg3-2
    on_disk2_peg1-2 clear_peg3-2 on_disk2_peg3-3 clear_peg1-3 (not on_disk2_peg1-3) (not
    clear_peg3-3)))
43 (:implies movedisk_disk2_peg2_disk1-2 (and clear_disk2-2 smaller_disk2_disk1-2
    on_disk2_peg2-2 clear_disk1-2 on_disk2_disk1-3 clear_peg2-3 (not on_disk2_peg2-3) (
    not clear_disk1-3)))

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44 (:implies movedisk_disk2_peg2_peg1-2 (and clear_disk2-2 smaller_disk2_peg1-2
    on_disk2_peg2-2 clear_peg1-2 on_disk2_peg1-3 clear_peg2-3 (not on_disk2_peg2-3) (not
    clear_peg1-3)))
45 (:implies movedisk_disk2_peg2_peg3-2 (and clear_disk2-2 smaller_disk2_peg3-2
    on_disk2_peg2-2 clear_peg3-2 on_disk2_peg3-3 clear_peg2-3 (not on_disk2_peg2-3) (not
    clear_peg3-3)))
46 (:implies movedisk_disk2_peg3_disk1-2 (and clear_disk2-2 smaller_disk2_disk1-2
    on_disk2_peg3-2 clear_disk1-2 on_disk2_disk1-3 clear_peg3-3 (not on_disk2_peg3-3) (
    not clear_disk1-3)))
47 (:implies movedisk_disk2_peg3_peg1-2 (and clear_disk2-2 smaller_disk2_peg1-2
    on_disk2_peg3-2 clear_peg1-2 on_disk2_peg1-3 clear_peg3-3 (not on_disk2_peg3-3) (not
    clear_peg1-3)))
48 (:implies movedisk_disk2_peg3_peg2-2 (and clear_disk2-2 smaller_disk2_peg2-2
    on_disk2_peg3-2 clear_peg2-2 on_disk2_peg2-3 clear_peg3-3 (not on_disk2_peg3-3) (not
    clear_peg2-3)))
49 (:implies movedisk_disk1_disk2_peg1-3 (and clear_disk1-3 smaller_disk1_peg1-3
    on_disk1_disk2-3 clear_peg1-3 on_disk1_peg1-4 clear_disk2-4 (not on_disk1_disk2-4) (
    not clear_peg1-4)))
50 (:implies movedisk_disk1_disk2_peg2-3 (and clear_disk1-3 smaller_disk1_peg2-3
    on_disk1_disk2-3 clear_peg2-3 on_disk1_peg2-4 clear_disk2-4 (not on_disk1_disk2-4) (
    not clear_peg2-4)))
51 (:implies movedisk_disk1_disk2_peg3-3 (and clear_disk1-3 smaller_disk1_peg3-3
    on_disk1_disk2-3 clear_peg3-3 on_disk1_peg3-4 clear_disk2-4 (not on_disk1_disk2-4) (
    not clear_peg3-4)))
52 (:implies movedisk_disk1_peg1_disk2-3 (and clear_disk1-3 smaller_disk1_disk2-3
    on_disk1_peg1-3 clear_disk2-3 on_disk1_disk2-4 clear_peg1-4 (not on_disk1_peg1-4) (
    not clear_disk2-4)))
53 (:implies movedisk_disk1_peg1_peg2-3 (and clear_disk1-3 smaller_disk1_peg2-3
    on_disk1_peg1-3 clear_peg2-3 on_disk1_peg2-4 clear_peg1-4 (not on_disk1_peg1-4) (not
    clear_peg2-4)))
54 (:implies movedisk_disk1_peg1_peg3-3 (and clear_disk1-3 smaller_disk1_peg3-3
    on_disk1_peg1-3 clear_peg3-3 on_disk1_peg3-4 clear_peg1-4 (not on_disk1_peg1-4) (not
    clear_peg3-4)))
55 (:implies movedisk_disk1_peg2_disk2-3 (and clear_disk1-3 smaller_disk1_disk2-3
    on_disk1_peg2-3 clear_disk2-3 on_disk1_disk2-4 clear_peg2-4 (not on_disk1_peg2-4) (
    not clear_disk2-4)))
56 (:implies movedisk_disk1_peg2_peg1-3 (and clear_disk1-3 smaller_disk1_peg1-3
    on_disk1_peg2-3 clear_peg1-3 on_disk1_peg1-4 clear_peg2-4 (not on_disk1_peg2-4) (not
    clear_peg1-4)))
57 (:implies movedisk_disk1_peg2_peg3-3 (and clear_disk1-3 smaller_disk1_peg3-3
    on_disk1_peg2-3 clear_peg3-3 on_disk1_peg3-4 clear_peg2-4 (not on_disk1_peg2-4) (not
    clear_peg3-4)))
58 (:implies movedisk_disk1_peg3_disk2-3 (and clear_disk1-3 smaller_disk1_disk2-3
    on_disk1_peg3-3 clear_disk2-3 on_disk1_disk2-4 clear_peg3-4 (not on_disk1_peg3-4) (
    not clear_disk2-4)))
59 (:implies movedisk_disk1_peg3_peg1-3 (and clear_disk1-3 smaller_disk1_peg1-3
    on_disk1_peg3-3 clear_peg1-3 on_disk1_peg1-4 clear_peg3-4 (not on_disk1_peg3-4) (not
    clear_peg1-4)))
60 (:implies movedisk_disk1_peg3_peg2-3 (and clear_disk1-3 smaller_disk1_peg2-3
    on_disk1_peg3-3 clear_peg2-3 on_disk1_peg2-4 clear_peg3-4 (not on_disk1_peg3-4) (not
    clear_peg2-4)))
61 (:implies movedisk_disk2_disk1_peg1-3 (and clear_disk2-3 smaller_disk2_peg1-3
    on_disk2_disk1-3 clear_peg1-3 on_disk2_peg1-4 clear_disk1-4 (not on_disk2_disk1-4) (
    not clear_peg1-4)))
62 (:implies movedisk_disk2_disk1_peg2-3 (and clear_disk2-3 smaller_disk2_peg2-3
    on_disk2_disk1-3 clear_peg2-3 on_disk2_peg2-4 clear_disk1-4 (not on_disk2_disk1-4) (
    not clear_peg2-4)))
63 (:implies movedisk_disk2_disk1_peg3-3 (and clear_disk2-3 smaller_disk2_peg3-3
    on_disk2_disk1-3 clear_peg3-3 on_disk2_peg3-4 clear_disk1-4 (not on_disk2_disk1-4) (
    not clear_peg3-4)))
64 (:implies movedisk_disk2_peg1_disk1-3 (and clear_disk2-3 smaller_disk2_disk1-3
    on_disk2_peg1-3 clear_disk1-3 on_disk2_disk1-4 clear_peg1-4 (not on_disk2_peg1-4) (
    not clear_disk1-4)))
65 (:implies movedisk_disk2_peg1_peg2-3 (and clear_disk2-3 smaller_disk2_peg2-3
    on_disk2_peg1-3 clear_peg2-3 on_disk2_peg2-4 clear_peg1-4 (not on_disk2_peg1-4) (not
    clear_peg2-4)))
66 (:implies movedisk_disk2_peg1_peg3-3 (and clear_disk2-3 smaller_disk2_peg3-3
    on_disk2_peg1-3 clear_peg3-3 on_disk2_peg3-4 clear_peg1-4 (not on_disk2_peg1-4) (not
    clear_peg3-4)))
67 (:implies movedisk_disk2_peg2_disk1-3 (and clear_disk2-3 smaller_disk2_disk1-3
    on_disk2_peg2-3 clear_disk1-3 on_disk2_disk1-4 clear_peg2-4 (not on_disk2_peg2-4) (
    not clear_disk1-4)))
68 (:implies movedisk_disk2_peg2_peg1-3 (and clear_disk2-3 smaller_disk2_peg1-3
    on_disk2_peg2-3 clear_peg1-3 on_disk2_peg1-4 clear_peg2-4 (not on_disk2_peg2-4) (not
    clear_peg1-4)))
69 (:implies movedisk_disk2_peg2_peg3-3 (and clear_disk2-3 smaller_disk2_peg3-3
    on_disk2_peg2-3 clear_peg3-3 on_disk2_peg3-4 clear_peg2-4 (not on_disk2_peg2-4) (not
    clear_peg3-4)))
70 (:implies movedisk_disk2_peg3_disk1-3 (and clear_disk2-3 smaller_disk2_disk1-3
    on_disk2_peg3-3 clear_disk1-3 on_disk2_disk1-4 clear_peg3-4 (not on_disk2_peg3-4) (
    not clear_disk1-4)))

```

```

71 (:implies movedisk_disk2_peg3_peg1-3 (and clear_disk2-3 smaller_disk2_peg1-3
      on_disk2_peg3-3 clear_peg1-3 on_disk2_peg1-4 clear_peg3-4 (not on_disk2_peg3-4) (not
      clear_peg1-4)))
72 (:implies movedisk_disk2_peg3_peg2-3 (and clear_disk2-3 smaller_disk2_peg2-3
      on_disk2_peg3-3 clear_peg2-3 on_disk2_peg2-4 clear_peg3-4 (not on_disk2_peg3-4) (not
      clear_peg2-4)))

```

(e) Operator Exclusion

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```

movedisk_disk2_peg1_peg3-3) (not movedisk_disk2_peg2_peg1-3) (not
movedisk_disk2_peg2_peg3-3) (not movedisk_disk2_peg3_disk1-3) (not
movedisk_disk2_peg3_peg1-3) (not movedisk_disk2_peg3_peg2-3)))
68 (:implies movedisk_disk2_peg2_peg1-3 (and (not movedisk_disk1_disk2_peg1-3) (not
movedisk_disk1_disk2_peg2-3) (not movedisk_disk1_disk2_peg3-3) (not
movedisk_disk1_peg1_disk2-3) (not movedisk_disk1_peg1_peg2-3) (not
movedisk_disk1_peg1_peg3-3) (not movedisk_disk1_peg2_disk2-3) (not
movedisk_disk1_peg2_peg1-3) (not movedisk_disk1_peg2_peg3-3) (not
movedisk_disk1_peg3_disk2-3) (not movedisk_disk1_peg3_peg1-3) (not
movedisk_disk1_peg3_peg2-3) (not movedisk_disk2_disk1_peg1-3) (not
movedisk_disk2_disk1_peg2-3) (not movedisk_disk2_disk1_peg3-3) (not
movedisk_disk2_peg1_disk1-3) (not movedisk_disk2_peg1_peg2-3) (not
movedisk_disk2_peg1_peg3-3) (not movedisk_disk2_peg2_disk1-3) (not
movedisk_disk2_peg2_peg3-3) (not movedisk_disk2_peg3_disk1-3) (not
movedisk_disk2_peg3_peg1-3) (not movedisk_disk2_peg3_peg2-3)))
69 (:implies movedisk_disk2_peg2_peg3-3 (and (not movedisk_disk1_disk2_peg1-3) (not
movedisk_disk1_disk2_peg2-3) (not movedisk_disk1_disk2_peg3-3) (not
movedisk_disk1_peg1_disk2-3) (not movedisk_disk1_peg1_peg2-3) (not
movedisk_disk1_peg1_peg3-3) (not movedisk_disk1_peg2_disk2-3) (not
movedisk_disk1_peg2_peg1-3) (not movedisk_disk1_peg2_peg3-3) (not
movedisk_disk1_peg3_disk2-3) (not movedisk_disk1_peg3_peg1-3) (not
movedisk_disk1_peg3_peg2-3) (not movedisk_disk2_disk1_peg1-3) (not
movedisk_disk2_disk1_peg2-3) (not movedisk_disk2_disk1_peg3-3) (not
movedisk_disk2_peg1_disk1-3) (not movedisk_disk2_peg1_peg2-3) (not
movedisk_disk2_peg1_peg3-3) (not movedisk_disk2_peg2_disk1-3) (not
movedisk_disk2_peg2_peg1-3) (not movedisk_disk2_peg2_peg3-3) (not
movedisk_disk2_peg3_peg1-3) (not movedisk_disk2_peg3_peg2-3)))
70 (:implies movedisk_disk2_peg3_disk1-3 (and (not movedisk_disk1_disk2_peg1-3) (not
movedisk_disk1_disk2_peg2-3) (not movedisk_disk1_disk2_peg3-3) (not
movedisk_disk1_peg1_disk2-3) (not movedisk_disk1_peg1_peg2-3) (not
movedisk_disk1_peg1_peg3-3) (not movedisk_disk1_peg2_disk2-3) (not
movedisk_disk1_peg2_peg1-3) (not movedisk_disk1_peg2_peg3-3) (not
movedisk_disk1_peg3_disk2-3) (not movedisk_disk1_peg3_peg1-3) (not
movedisk_disk1_peg3_peg2-3) (not movedisk_disk2_disk1_peg1-3) (not
movedisk_disk2_disk1_peg2-3) (not movedisk_disk2_disk1_peg3-3) (not
movedisk_disk2_peg1_disk1-3) (not movedisk_disk2_peg1_peg2-3) (not
movedisk_disk2_peg1_peg3-3) (not movedisk_disk2_peg2_disk1-3) (not
movedisk_disk2_peg2_peg1-3) (not movedisk_disk2_peg2_peg3-3) (not
movedisk_disk2_peg3_peg1-3) (not movedisk_disk2_peg3_peg2-3)))
71 (:implies movedisk_disk2_peg3_peg1-3 (and (not movedisk_disk1_disk2_peg1-3) (not
movedisk_disk1_disk2_peg2-3) (not movedisk_disk1_disk2_peg3-3) (not
movedisk_disk1_peg1_disk2-3) (not movedisk_disk1_peg1_peg2-3) (not
movedisk_disk1_peg1_peg3-3) (not movedisk_disk1_peg2_disk2-3) (not
movedisk_disk1_peg2_peg1-3) (not movedisk_disk1_peg2_peg3-3) (not
movedisk_disk1_peg3_disk2-3) (not movedisk_disk1_peg3_peg1-3) (not
movedisk_disk1_peg3_peg2-3) (not movedisk_disk2_disk1_peg1-3) (not
movedisk_disk2_disk1_peg2-3) (not movedisk_disk2_disk1_peg3-3) (not
movedisk_disk2_peg1_disk1-3) (not movedisk_disk2_peg1_peg2-3) (not
movedisk_disk2_peg1_peg3-3) (not movedisk_disk2_peg2_disk1-3) (not
movedisk_disk2_peg2_peg1-3) (not movedisk_disk2_peg2_peg3-3) (not
movedisk_disk2_peg3_disk1-3) (not movedisk_disk2_peg3_peg2-3)))
72 (:implies movedisk_disk2_peg3_peg2-3 (and (not movedisk_disk1_disk2_peg1-3) (not
movedisk_disk1_disk2_peg2-3) (not movedisk_disk1_disk2_peg3-3) (not
movedisk_disk1_peg1_disk2-3) (not movedisk_disk1_peg1_peg2-3) (not
movedisk_disk1_peg1_peg3-3) (not movedisk_disk1_peg2_disk2-3) (not
movedisk_disk1_peg2_peg1-3) (not movedisk_disk1_peg2_peg3-3) (not
movedisk_disk1_peg3_disk2-3) (not movedisk_disk1_peg3_peg1-3) (not
movedisk_disk1_peg3_peg2-3) (not movedisk_disk2_disk1_peg1-3) (not
movedisk_disk2_disk1_peg2-3) (not movedisk_disk2_disk1_peg3-3) (not
movedisk_disk2_peg1_disk1-3) (not movedisk_disk2_peg1_peg2-3) (not
movedisk_disk2_peg1_peg3-3) (not movedisk_disk2_peg2_disk1-3) (not
movedisk_disk2_peg2_peg1-3) (not movedisk_disk2_peg2_peg3-3) (not
movedisk_disk2_peg3_disk1-3) (not movedisk_disk2_peg3_peg1-3)))

```

4. Find the satisfying assignments for the three-peg, two-disk Boolean formula using your DPLL implementation.

(a) What is the satisfying assignment?

If a literal is not inside a NOT clause, it is bound to true. If a literal is inside a NOT clause, it is bound to false.

- 1 (NOT ON_DISK1_PEG3-4)
- 2 (NOT ON_DISK1_PEG1-4)
- 3 (NOT ON_DISK2_PEG1-4)
- 4 CLEAR_PEG1-4
- 5 CLEAR_PEG1-3
- 6 ON_DISK2_PEG3-3
- 7 (NOT ON_DISK2_PEG1-3)

```

8 MOVEDISK_DISK2.PEG1.PEG3-2
9 (NOT MOVEDISK_DISK1.PEG2.PEG1-3)
10 (NOT CLEAR_PEG3-3)
11 (NOT MOVEDISK_DISK1.PEG2.PEG3-3)
12 (NOT ON_DISK1.PEG3-3)
13 (NOT MOVEDISK_DISK2.PEG1.PEG3-3)
14 (NOT CLEAR_PEG2-3)
15 (NOT ON_DISK1.PEG2-4)
16 (NOT MOVEDISK_DISK1.PEG2.PEG3-2)
17 (NOT CLEAR_DISK2-4)
18 ON_DISK1.PEG2-3
19 MOVEDISK_DISK1.PEG2_DISK2-3
20 CLEAR_DISK2-3
21 (NOT MOVEDISK_DISK1.PEG2_DISK2-2)
22 (NOT ON_DISK1_DISK2-3)
23 (NOT MOVEDISK_DISK1.PEG3_DISK2-2)
24 (NOT ON_DISK1.PEG3-2)
25 (NOT MOVEDISK_DISK2.PEG2.PEG3-3)
26 (NOT MOVEDISK_DISK2.PEG2.PEG1-3)
27 (NOT ON_DISK2.PEG2-3)
28 CLEAR_PEG3-2
29 (NOT MOVEDISK_DISK1_DISK2.PEG3-1)
30 (NOT MOVEDISK_DISK1_DISK2.PEG3-2)
31 (NOT MOVEDISK_DISK1.PEG3.PEG2-2)
32 (NOT MOVEDISK_DISK1_DISK2.PEG2-2)
33 (NOT MOVEDISK_DISK2.PEG1.PEG2-2)
34 (NOT ON_DISK1_DISK2-2)
35 (NOT CLEAR_PEG2-2)
36 CLEAR_DISK2-2
37 MOVEDISK_DISK1_DISK2.PEG2-1
38 ON_DISK1.PEG2-2
39 CLEAR_PEG2-4
40 (NOT MOVEDISK_DISK2.PEG1.PEG2-3)
41 (NOT ON_DISK2.PEG2-4)
42 (NOT MOVEDISK_DISK1.PEG3.PEG1-3)
43 (NOT MOVEDISK_DISK1.PEG3.PEG2-3)
44 (NOT MOVEDISK_DISK1.PEG3_DISK2-3)
45 (NOT CLEAR_PEG3-4)
46 (NOT ON_DISK2_DISK1-4)
47 (NOT SMALLER_DISK1_DISK1-4)
48 CLEAR_DISK1-4
49 (NOT SMALLER_PEG3.PEG1-4)
50 (NOT SMALLER_PEG3.PEG1-3)
51 (NOT SMALLER_PEG3_DISK1-4)
52 (NOT SMALLER_PEG3_DISK1-3)
53 (NOT SMALLER_PEG2.PEG2-4)
54 (NOT SMALLER_PEG2.PEG2-3)
55 (NOT SMALLER_PEG2_DISK2-4)
56 (NOT SMALLER_PEG2_DISK2-3)
57 (NOT SMALLER_PEG1.PEG3-4)
58 (NOT SMALLER_PEG1.PEG3-3)
59 (NOT SMALLER_PEG1.PEG1-4)
60 (NOT SMALLER_PEG1.PEG1-3)
61 (NOT SMALLER_PEG1_DISK1-4)
62 (NOT SMALLER_PEG1_DISK1-3)
63 SMALLER_DISK2.PEG2-4
64 SMALLER_DISK2.PEG2-3
65 (NOT SMALLER_DISK2_DISK2-4)
66 (NOT SMALLER_DISK2_DISK2-3)
67 (NOT SMALLER_PEG3.PEG3-4)
68 (NOT SMALLER_DISK1_DISK1-3)
69 (NOT MOVEDISK_DISK2_DISK1.PEG2-3)
70 (NOT MOVEDISK_DISK2_DISK1.PEG1-3)
71 (NOT MOVEDISK_DISK2_DISK1.PEG3-3)
72 (NOT ON_DISK2_DISK1-3)
73 (NOT MOVEDISK_DISK1.PEG1.PEG2-3)
74 (NOT MOVEDISK_DISK1.PEG1_DISK2-3)
75 (NOT MOVEDISK_DISK1.PEG1.PEG3-3)
76 (NOT ON_DISK1.PEG1-3)
77 (NOT SMALLER_PEG3.PEG3-3)
78 CLEAR_DISK1-3
79 (NOT SMALLER_PEG3.PEG2-4)
80 (NOT SMALLER_PEG3.PEG3-2)
81 (NOT SMALLER_PEG3.PEG2-3)
82 (NOT SMALLER_PEG3.PEG2-2)
83 (NOT SMALLER_PEG3_DISK2-4)
84 (NOT SMALLER_PEG3.PEG1-2)
85 (NOT SMALLER_PEG3_DISK2-3)
86 (NOT SMALLER_PEG3_DISK2-2)
87 (NOT SMALLER_PEG2.PEG3-4)
88 (NOT SMALLER_PEG3_DISK1-2)

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```

89 (NOT SMALLER_PEG2.PEG3-3)
90 (NOT SMALLER_PEG2.PEG3-2)
91 (NOT SMALLER_PEG2.PEG1-4)
92 (NOT SMALLER_PEG2.PEG2-2)
93 (NOT SMALLER_PEG2.PEG1-3)
94 (NOT SMALLER_PEG2.PEG1-2)
95 (NOT SMALLER_PEG2.DISK1-4)
96 (NOT SMALLER_PEG2.DISK2-2)
97 (NOT SMALLER_PEG2.DISK1-3)
98 (NOT SMALLER_PEG2.DISK1-2)
99 (NOT SMALLER_PEG1.PEG2-4)
100 (NOT SMALLER_PEG1.PEG3-2)
101 (NOT SMALLER_PEG1.PEG2-3)
102 (NOT SMALLER_PEG1.PEG2-2)
103 (NOT SMALLER_PEG1.DISK2-4)
104 (NOT SMALLER_PEG1.PEG1-2)
105 (NOT SMALLER_PEG1.DISK2-3)
106 (NOT SMALLER_PEG1.DISK2-2)
107 SMALLER_DISK2.PEG3-4
108 (NOT SMALLER_PEG1.DISK1-2)
109 SMALLER_DISK2.PEG3-3
110 SMALLER_DISK2.PEG3-2
111 SMALLER_DISK2.PEG1-4
112 SMALLER_DISK2.PEG2-2
113 SMALLER_DISK2.PEG1-3
114 SMALLER_DISK2.PEG1-2
115 SMALLER_DISK1.DISK2-4
116 (NOT SMALLER_DISK2.DISK2-2)
117 (NOT MOVEDISK_DISK2.PEG3.PEG2-2)
118 (NOT ON_DISK2.PEG3-2)
119 (NOT MOVEDISK_DISK2.PEG2.PEG3-2)
120 (NOT ON_DISK2.PEG2-2)
121 SMALLER_DISK1.DISK2-3
122 ON_DISK2.PEG1-2
123 SMALLER_DISK1.PEG1-4
124 (NOT MOVEDISK_DISK2.DISK1.PEG2-2)
125 (NOT MOVEDISK_DISK2.DISK1.PEG3-2)
126 (NOT ON_DISK2.DISK1-2)
127 (NOT MOVEDISK_DISK1.PEG1.PEG2-2)
128 (NOT MOVEDISK_DISK1.PEG1.DISK2-2)
129 (NOT MOVEDISK_DISK1.PEG1.PEG3-2)
130 (NOT ON_DISK1.PEG1-2)
131 SMALLER_DISK1.PEG1-3
132 (NOT MOVEDISK_DISK1.PEG3.PEG1-2)
133 (NOT MOVEDISK_DISK2.DISK1.PEG1-2)
134 (NOT MOVEDISK_DISK1.PEG2.PEG1-2)
135 (NOT MOVEDISK_DISK2.PEG2.PEG1-2)
136 (NOT MOVEDISK_DISK1.DISK2.PEG1-2)
137 (NOT MOVEDISK_DISK2.PEG3.PEG1-2)
138 (NOT CLEAR_PEG1-2)
139 SMALLER_DISK1.PEG2-4
140 CLEAR_DISK1-2
141 SMALLER_DISK1.PEG2-3
142 (NOT ON_DISK2.PEG3-1)
143 SMALLER_DISK1.PEG3-4
144 ON_DISK2.PEG1-1
145 (NOT MOVEDISK_DISK1.PEG3.PEG2-1)
146 (NOT ON_DISK1.PEG3-1)
147 (NOT MOVEDISK_DISK1.PEG2.PEG3-1)
148 (NOT ON_DISK1.PEG2-1)
149 SMALLER_DISK1.PEG3-3
150 CLEAR_PEG3-1
151 (NOT SMALLER_DISK2.DISK1-4)
152 CLEAR_PEG2-1
153 (NOT MOVEDISK_DISK1.PEG2.PEG1-1)
154 (NOT MOVEDISK_DISK1.DISK2.PEG1-1)
155 (NOT MOVEDISK_DISK1.PEG3.PEG1-1)
156 (NOT CLEAR_PEG1-1)
157 (NOT MOVEDISK_DISK2.PEG2.DISK1-3)
158 (NOT MOVEDISK_DISK2.PEG1.DISK1-3)
159 (NOT SMALLER_DISK2.DISK1-3)
160 CLEAR_DISK1-1
161 (NOT MOVEDISK_DISK2.PEG1.PEG3-1)
162 (NOT MOVEDISK_DISK2.PEG1.PEG2-1)
163 (NOT MOVEDISK_DISK2.PEG3.PEG1-1)
164 (NOT MOVEDISK_DISK1.PEG3.DISK2-1)
165 (NOT MOVEDISK_DISK2.PEG3.PEG2-1)
166 (NOT MOVEDISK_DISK1.PEG2.DISK2-1)
167 CLEAR_DISK1-0
168 (NOT CLEAR_DISK2-1)
169 (NOT CLEAR_DISK2-0)

```

```

170 (NOT MOVEDISK_DISK1_PEG1_PEG3-1)
171 (NOT CLEAR_PEG1-0)
172 (NOT MOVEDISK_DISK1_PEG1_PEG2-1)
173 CLEAR_PEG2-0
174 (NOT MOVEDISK_DISK1_PEG1_DISK2-1)
175 CLEAR_PEG3-0
176 (NOT ON_DISK1_PEG1-1)
177 (NOT ON_DISK1_DISK1-0)
178 ON_DISK1_DISK2-1
179 ON_DISK1_DISK2-0
180 (NOT MOVEDISK_DISK2_DISK1_PEG3-1)
181 (NOT ON_DISK1_PEG1-0)
182 (NOT MOVEDISK_DISK2_DISK1_PEG2-1)
183 (NOT ON_DISK1_PEG2-0)
184 (NOT MOVEDISK_DISK2_DISK1_PEG1-1)
185 (NOT ON_DISK1_PEG3-0)
186 (NOT ON_DISK2_DISK1-1)
187 (NOT ON_DISK2_DISK1-0)
188 (NOT MOVEDISK_DISK2_PEG2_PEG3-1)
189 (NOT ON_DISK2_DISK2-0)
190 (NOT MOVEDISK_DISK2_PEG2_PEG1-1)
191 ON_DISK2_PEG1-0
192 (NOT ON_DISK2_PEG2-1)
193 (NOT ON_DISK2_PEG2-0)
194 (NOT MOVEDISK_DISK2_PEG3_DISK1-2)
195 (NOT ON_DISK2_PEG3-0)
196 (NOT MOVEDISK_DISK2_PEG2_DISK1-2)
197 (NOT ON_PEG1_DISK1-0)
198 (NOT MOVEDISK_DISK2_PEG1_DISK1-2)
199 (NOT ON_PEG1_DISK2-0)
200 (NOT SMALLER_DISK2_DISK1-2)
201 (NOT ON_PEG1_PEG1-0)
202 SMALLER_DISK1_PEG3-2
203 (NOT ON_PEG1_PEG2-0)
204 SMALLER_DISK1_PEG2-2
205 (NOT ON_PEG1_PEG3-0)
206 SMALLER_DISK1_PEG1-2
207 (NOT ON_PEG2_DISK1-0)
208 SMALLER_DISK1_DISK2-2
209 (NOT ON_PEG2_DISK2-0)
210 (NOT SMALLER_DISK1_DISK1-2)
211 (NOT ON_PEG2_PEG1-0)
212 (NOT SMALLER_PEG3_PEG3-1)
213 (NOT ON_PEG2_PEG2-0)
214 (NOT SMALLER_PEG3_PEG2-1)
215 (NOT ON_PEG2_PEG3-0)
216 (NOT SMALLER_PEG3_PEG1-1)
217 (NOT ON_PEG3_DISK1-0)
218 (NOT SMALLER_PEG3_DISK2-1)
219 (NOT ON_PEG3_DISK2-0)
220 SMALLER_DISK1_PEG3-1
221 (NOT ON_PEG3_PEG1-0)
222 SMALLER_DISK1_PEG2-1
223 (NOT ON_PEG3_PEG2-0)
224 SMALLER_DISK1_PEG1-1
225 (NOT ON_PEG3_PEG3-0)
226 (NOT SMALLER_DISK1_DISK1-1)
227 (NOT SMALLER_DISK1_DISK1-0)
228 SMALLER_DISK1_DISK2-1
229 SMALLER_DISK1_DISK2-0
230 (NOT MOVEDISK_DISK2_PEG3_DISK1-1)
231 SMALLER_DISK1_PEG1-0
232 (NOT MOVEDISK_DISK2_PEG2_DISK1-1)
233 SMALLER_DISK1_PEG2-0
234 (NOT MOVEDISK_DISK2_PEG1_DISK1-1)
235 SMALLER_DISK1_PEG3-0
236 (NOT SMALLER_DISK2_DISK1-1)
237 (NOT SMALLER_DISK2_DISK1-0)
238 (NOT SMALLER_DISK2_DISK2-1)
239 (NOT SMALLER_DISK2_DISK2-0)
240 SMALLER_DISK2_PEG1-1
241 SMALLER_DISK2_PEG1-0
242 SMALLER_DISK2_PEG2-1
243 SMALLER_DISK2_PEG2-0
244 SMALLER_DISK2_PEG3-1
245 SMALLER_DISK2_PEG3-0
246 (NOT SMALLER_PEG1_DISK1-1)
247 (NOT SMALLER_PEG1_DISK1-0)
248 (NOT SMALLER_PEG1_DISK2-1)
249 (NOT SMALLER_PEG1_DISK2-0)
250 (NOT SMALLER_PEG1_PEG1-1)

```

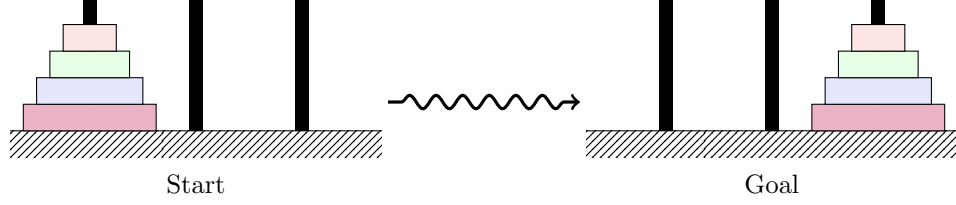


Figure 1: Tower of Hanoi Puzzle with 3 pegs and 4 disks.

```

251 (NOT SMALLER_PEG1_PEG1-0)
252 (NOT SMALLER_PEG1_PEG2-1)
253 (NOT SMALLER_PEG1_PEG2-0)
254 (NOT SMALLER_PEG1_PEG3-1)
255 (NOT SMALLER_PEG1_PEG3-0)
256 (NOT SMALLER_PEG2_DISK1-1)
257 (NOT SMALLER_PEG2_DISK1-0)
258 (NOT SMALLER_PEG2_DISK2-1)
259 (NOT SMALLER_PEG2_DISK2-0)
260 (NOT SMALLER_PEG2_PEG1-1)
261 (NOT SMALLER_PEG2_PEG1-0)
262 (NOT SMALLER_PEG2_PEG2-1)
263 (NOT SMALLER_PEG2_PEG2-0)
264 (NOT SMALLER_PEG2_PEG3-1)
265 (NOT SMALLER_PEG2_PEG3-0)
266 (NOT SMALLER_PEG3_DISK1-1)
267 (NOT SMALLER_PEG3_DISK1-0)
268 (NOT MOVEDISK_DISK2_PEG3_PEG2-3)
269 (NOT SMALLER_PEG3_DISK2-0)
270 (NOT MOVEDISK_DISK2_PEG3_PEG1-3)
271 (NOT SMALLER_PEG3_PEG1-0)
272 (NOT MOVEDISK_DISK1_DISK2_PEG3-3)
273 (NOT SMALLER_PEG3_PEG2-0)
274 (NOT MOVEDISK_DISK1_DISK2_PEG2-3)
275 (NOT SMALLER_PEG3_PEG3-0)
276 (NOT MOVEDISK_DISK1_DISK2_PEG1-3)
277 ON_DISK1_DISK2-4
278 (NOT MOVEDISK_DISK2_PEG3_DISK1-3)
279 ON_DISK2_PEG3-4

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(b) What is the corresponding plan?

- 1 MOVEDISK_DISK1_DISK2_PEG2-1
- 2 MOVEDISK_DISK2_PEG1_PEG3-2
- 3 MOVEDISK_DISK1_PEG2_DISK2-3