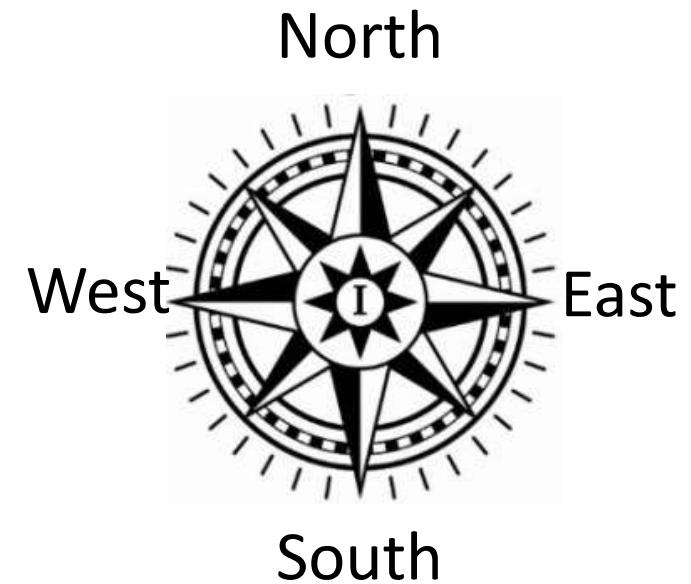
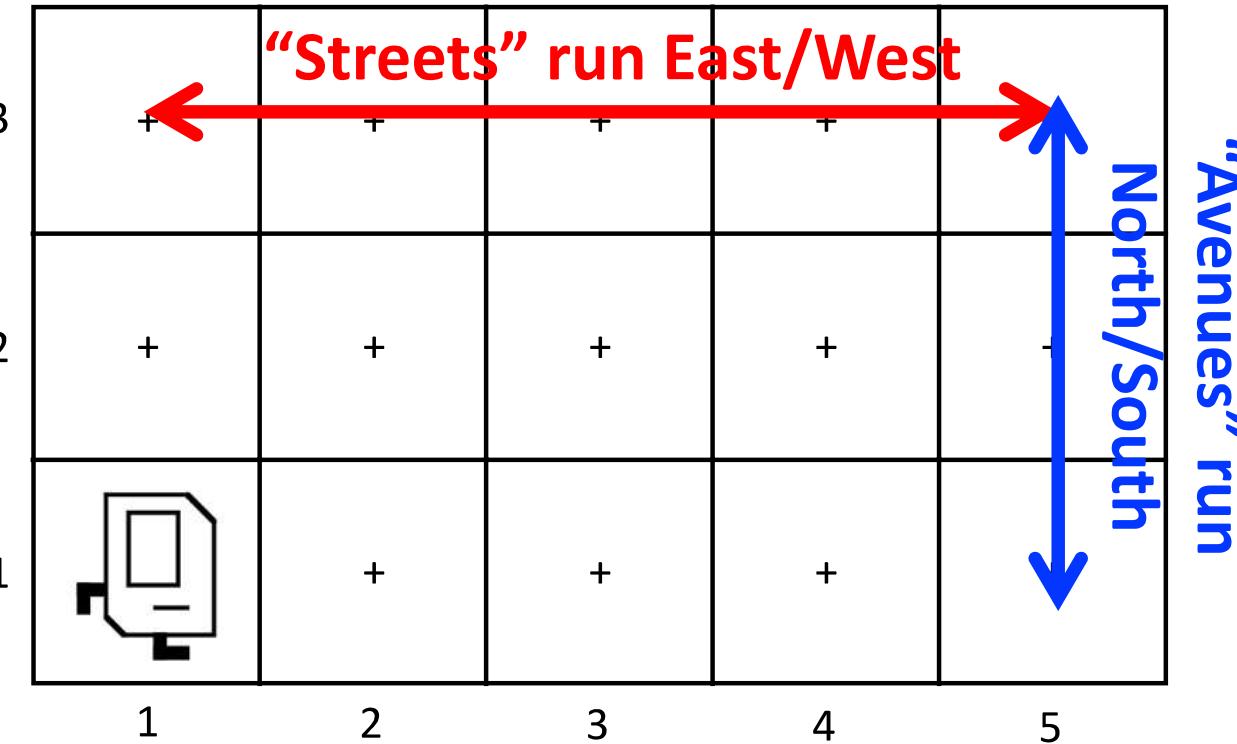




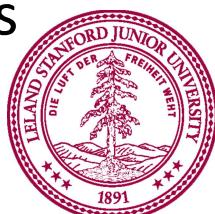
Control Flow

Chris Piech and Mehran Sahami
CS106A, Stanford University

Recall, Karel's World



- Grid, where “corner” is intersection of each street/avenue
- Karel is currently on corner (1, 1)
- If Karel moved forward, Karel would be on corner (2, 1)
- Karel’s beeper bag can have 0, 1, or more (up to infinite) beepers



First Lesson in Programming Style

```
from karel.stanfordkarel import *
```

```
"""
```

File: StepUpKarel.py

```
-----
```

Karel program, where Karel picks up a beeper,
jumps up on a step and drops the beeper off.

```
"""
```

```
def main():
    move()
    pick_beeper()
    move()
    turn_left()
    move()
    turn_right()
    move()
    put_beeper()
    move()
```

Karel turns to the right

```
def turn_right():
    turn_left()
    turn_left()
    turn_left()
```

} } Multi-line
comment

SOFTWARE ENGINEERING PRINCIPLE:
Aim to make programs readable by *humans*

} One line
comment

Descriptive
names
(snake_case)

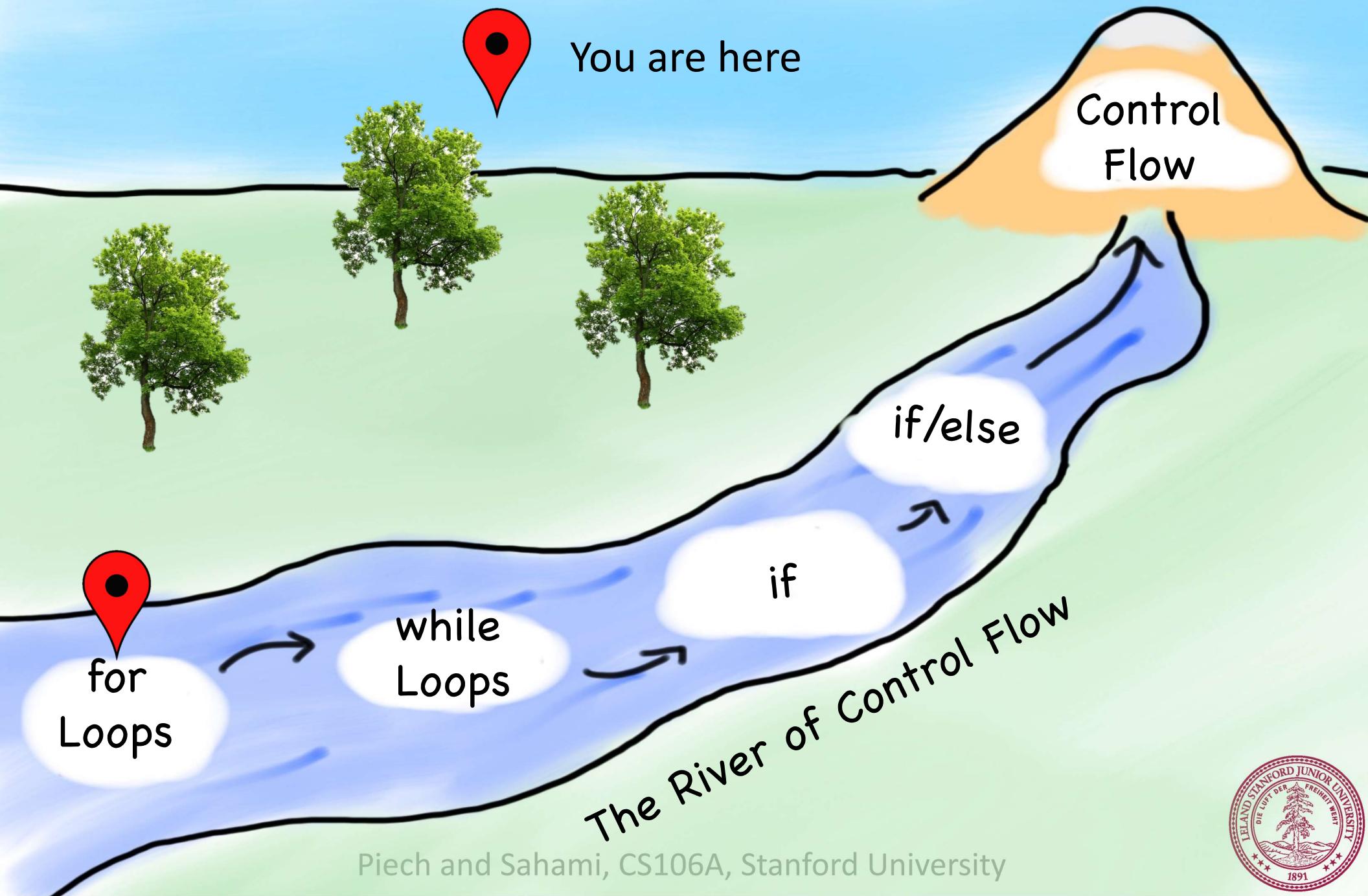


Today's Goal

1. Code using loops and conditions
2. Trace programs that use loops and conditions



Today's Route



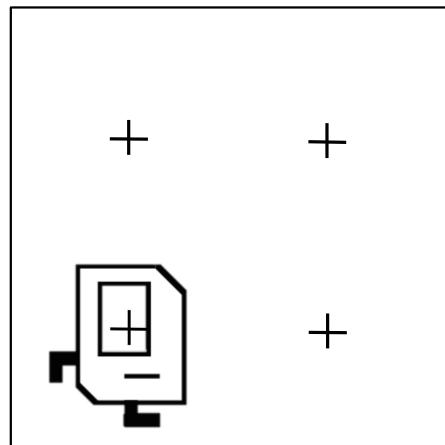
for loop

```
for i in range(count) :  
    statements                      # note indenting
```

```
def turn_right() :  
    for i in range(3) :  
        turn_left()    # note indenting
```

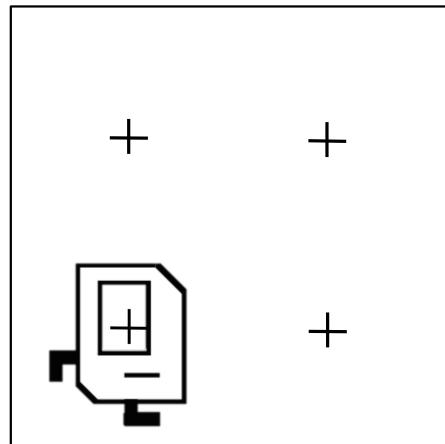
Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```



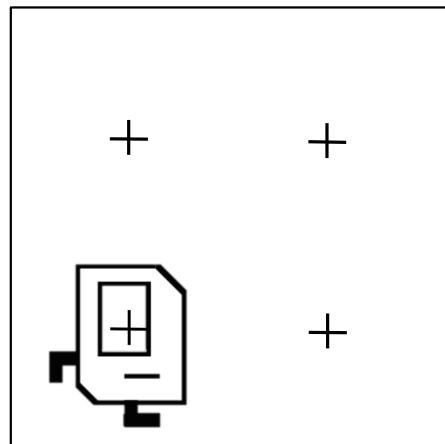
Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```



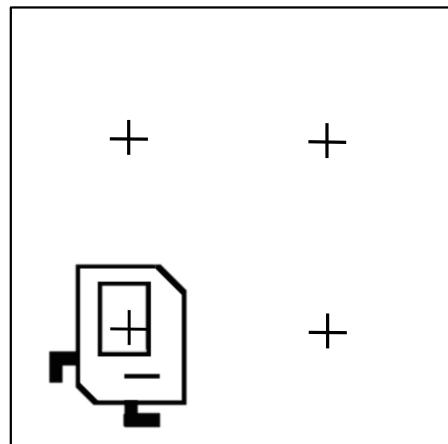
Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

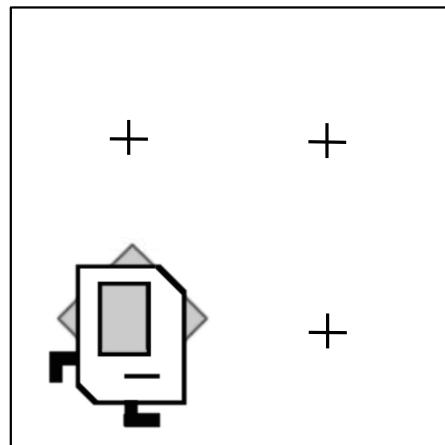


First time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

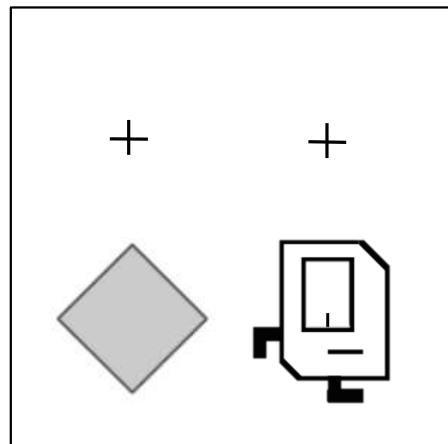


First time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

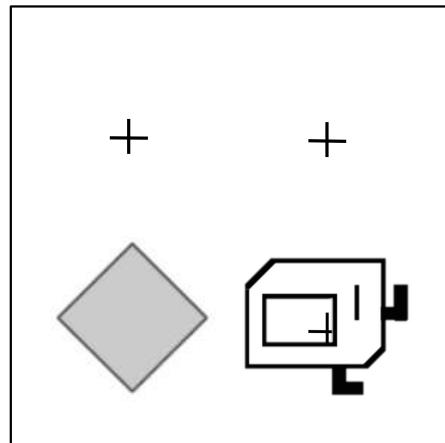


First time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

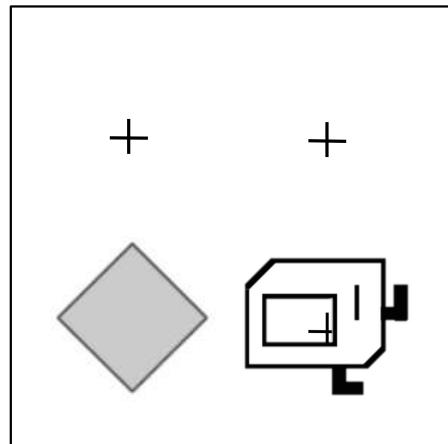


First time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

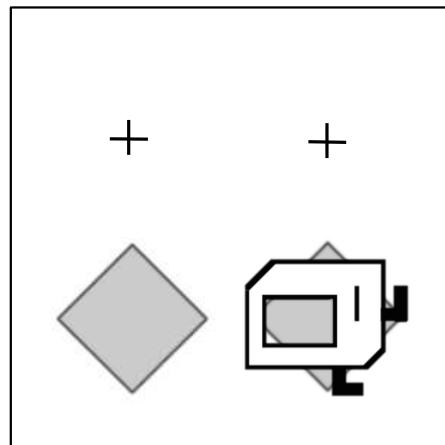


Second time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

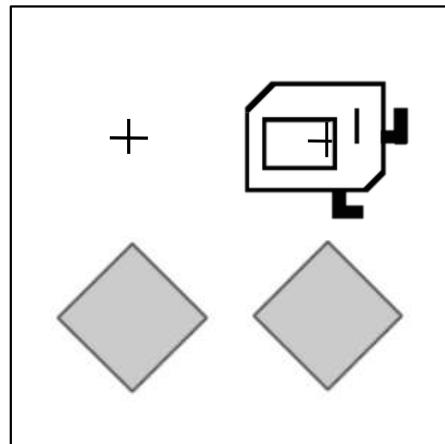


Second time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

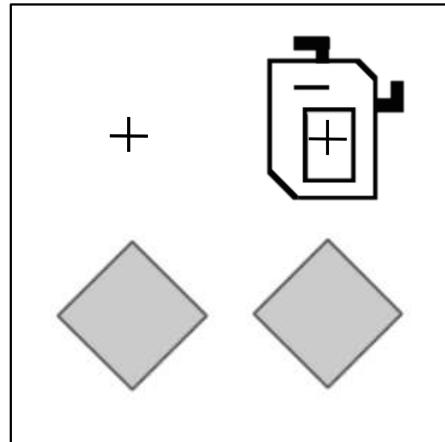


Second time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

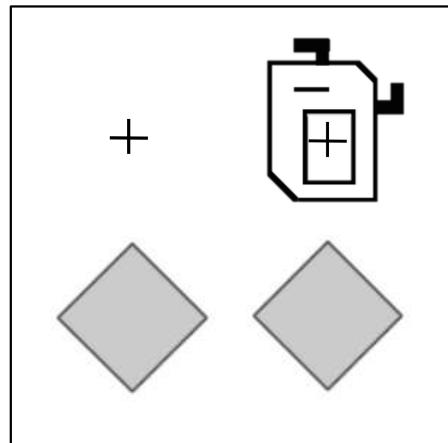


Second time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

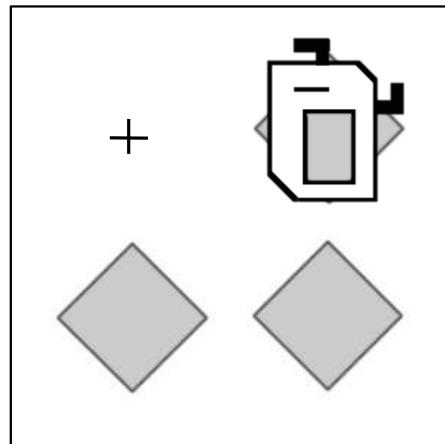


Third time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

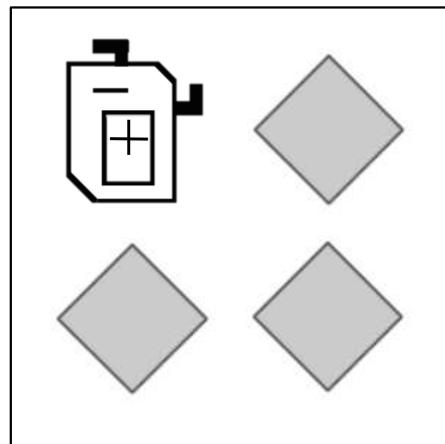


Third time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

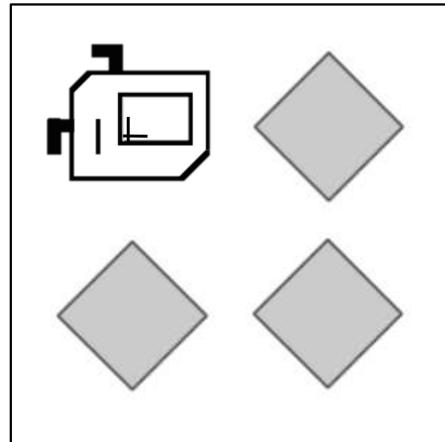


Third time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

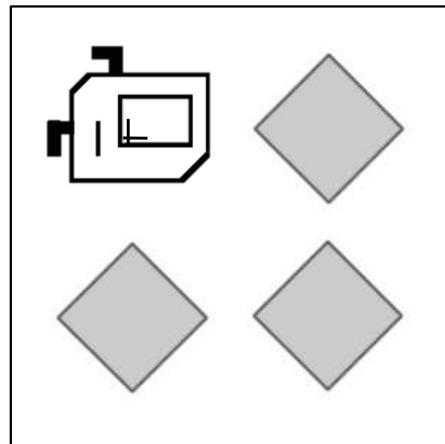


Third time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

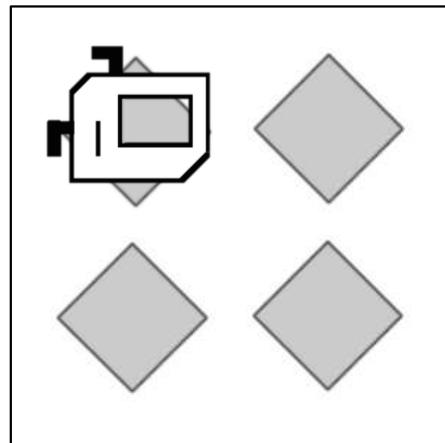


Fourth time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

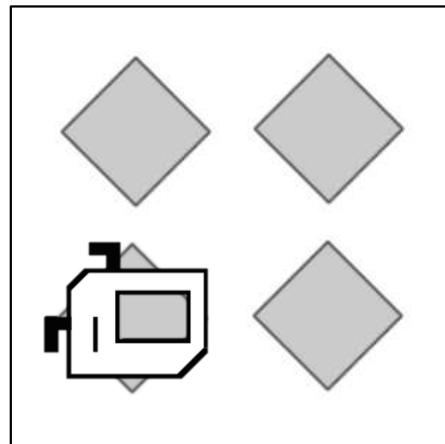


Fourth time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

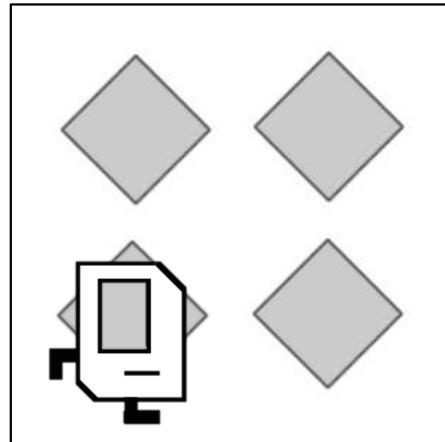


Fourth time
through the
loop



Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```



Fourth time
through the
loop



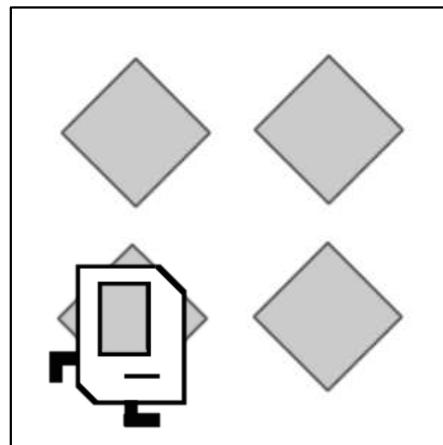
Place Beeper Square

```
def main():
    for i in range(4):
        put_beeper()
        move()
        turn_left()
```

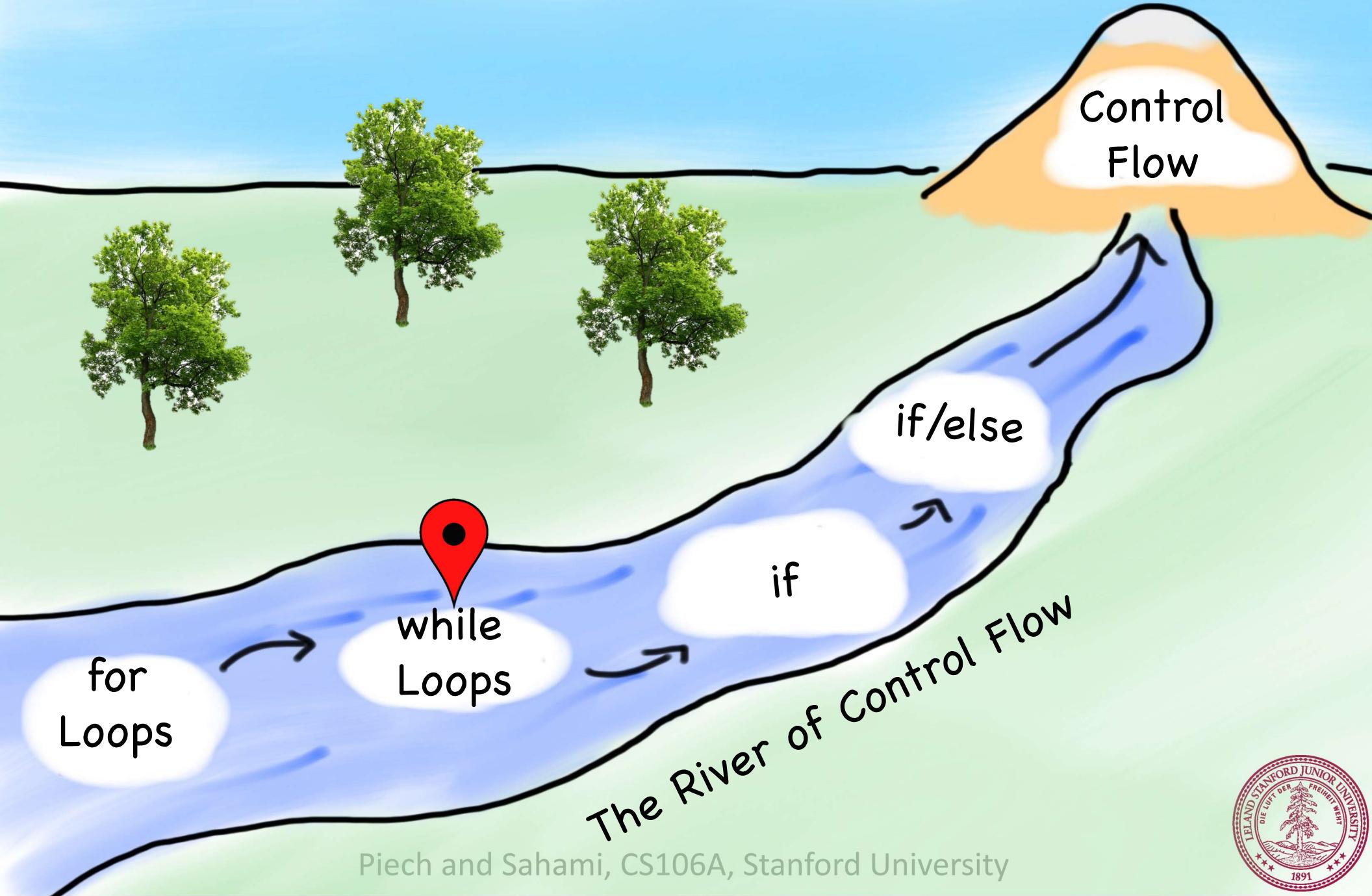


You need the **postcondition** of a loop to match the **precondition**

Done!



Today's Route



while loop

```
while condition:
```

statements

note indenting

```
def move_to_wall():
```

```
    while front_is_clear():
```

move()

note indenting

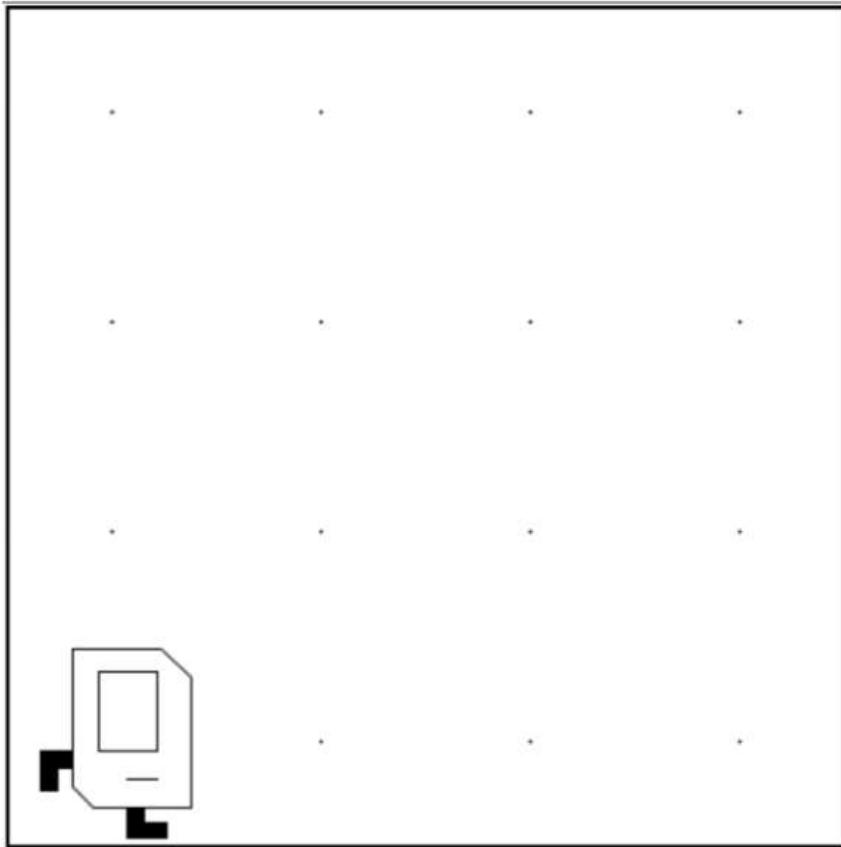
Conditions Karel Can Check For

<i>Test</i>	<i>Opposite</i>	<i>What it checks</i>
<code>front_is_clear()</code>	<code>front_is_blocked()</code>	Is there a wall in front of Karel?
<code>left_is_clear()</code>	<code>left_is_blocked()</code>	Is there a wall to Karel's left?
<code>right_is_clear()</code>	<code>right_is_blocked()</code>	Is there a wall to Karel's right?
<code>beepers_present()</code>	<code>no_beeper_present()</code>	Are there beepers on this corner?
<code>beepers_in_bag()</code>	<code>no_beeper_in_bag()</code>	Any there beepers in Karel's bag?
<code>facing_north()</code>	<code>not_facing_north()</code>	Is Karel facing north?
<code>facing_east()</code>	<code>not_facing_east()</code>	Is Karel facing east?
<code>facing_south()</code>	<code>not_facing_south()</code>	Is Karel facing south?
<code>facing_west()</code>	<code>not_facing_west()</code>	Is Karel facing west?

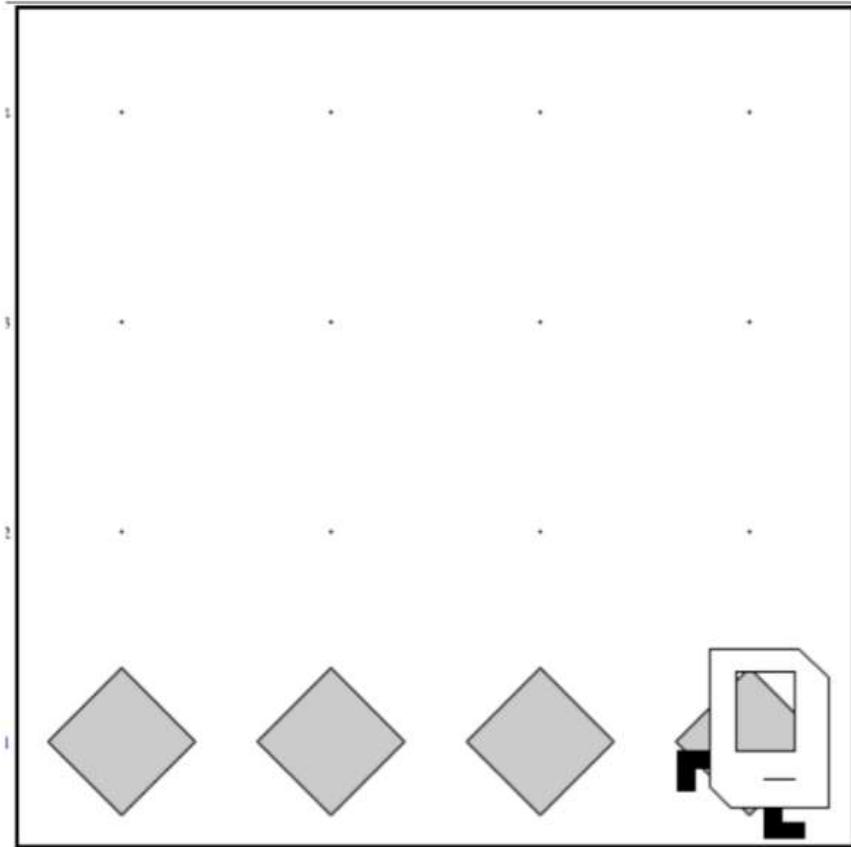
This is in Chapter 10 of the Karel course reader

Task: Place Beeper Line

Before



After



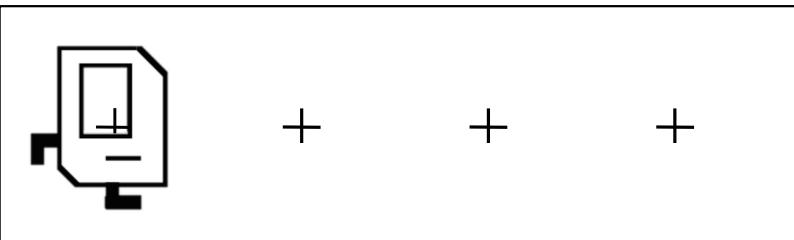
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



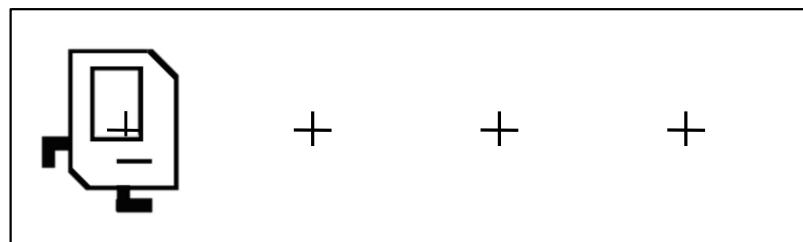
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



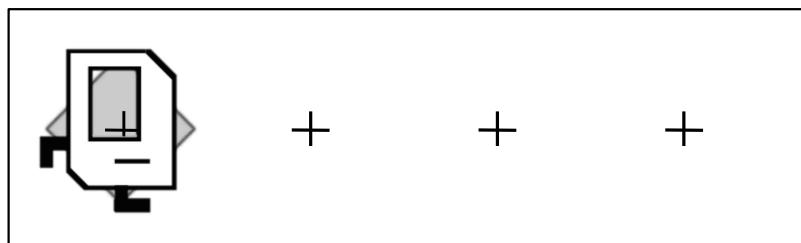
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



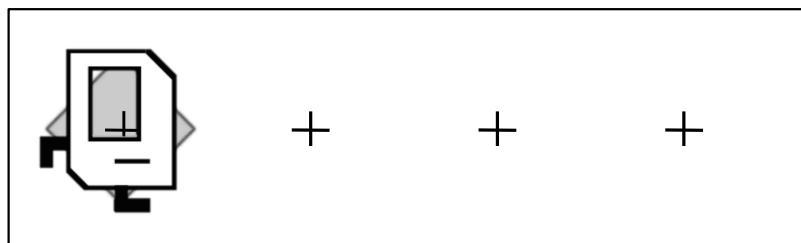
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
    move()
```



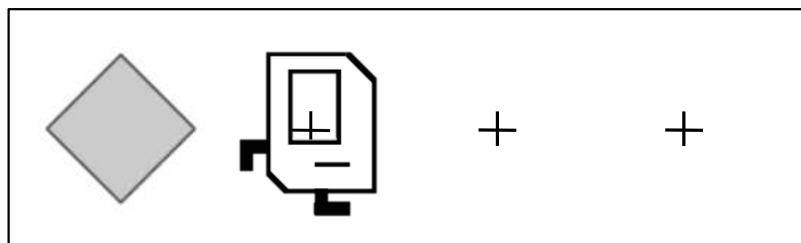
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



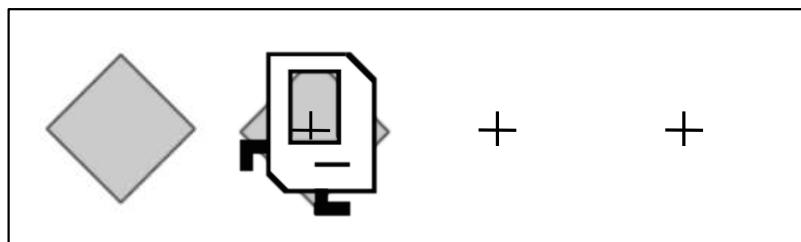
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



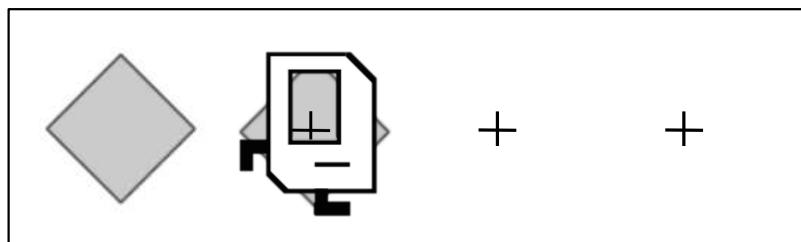
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



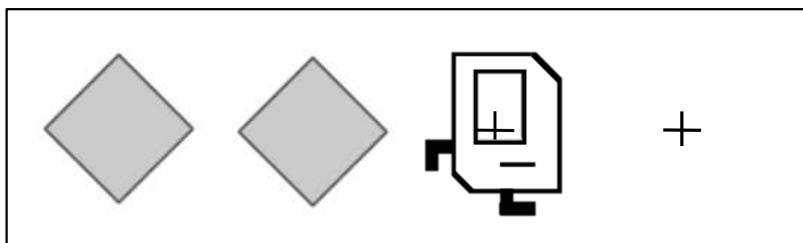
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



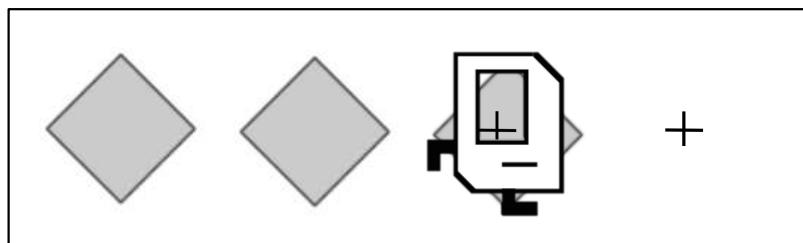
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



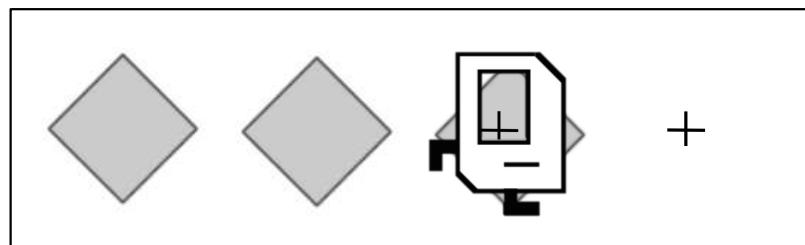
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
    move()
```



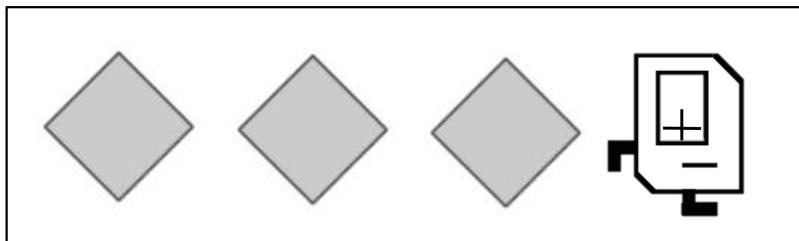
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



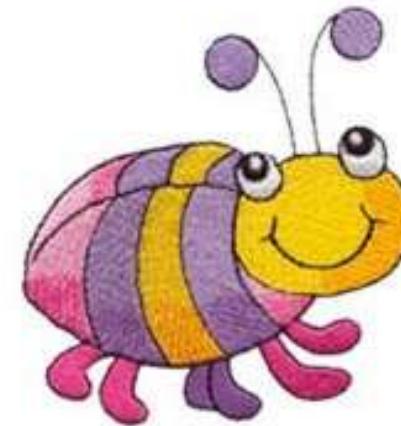
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



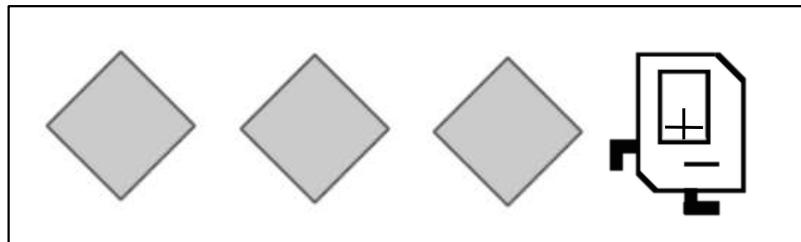
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
```



BUGGY!

Done!



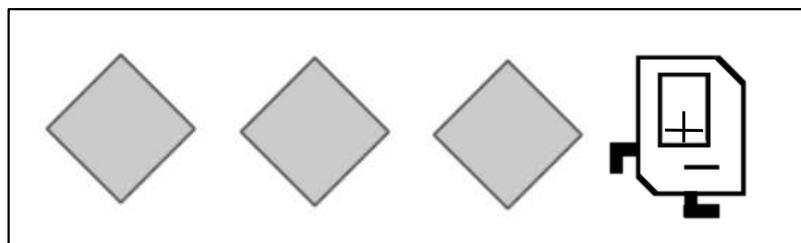
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
    put_beeper() # add final put_beeper
```



Not in **while** loop

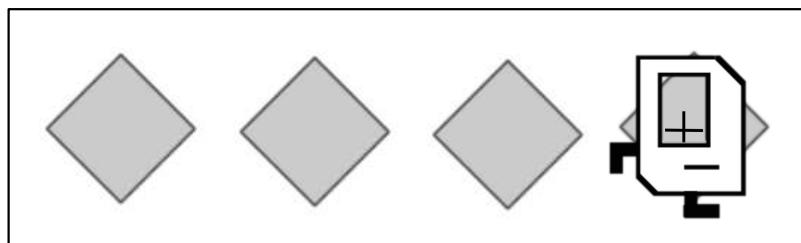
Fixed!



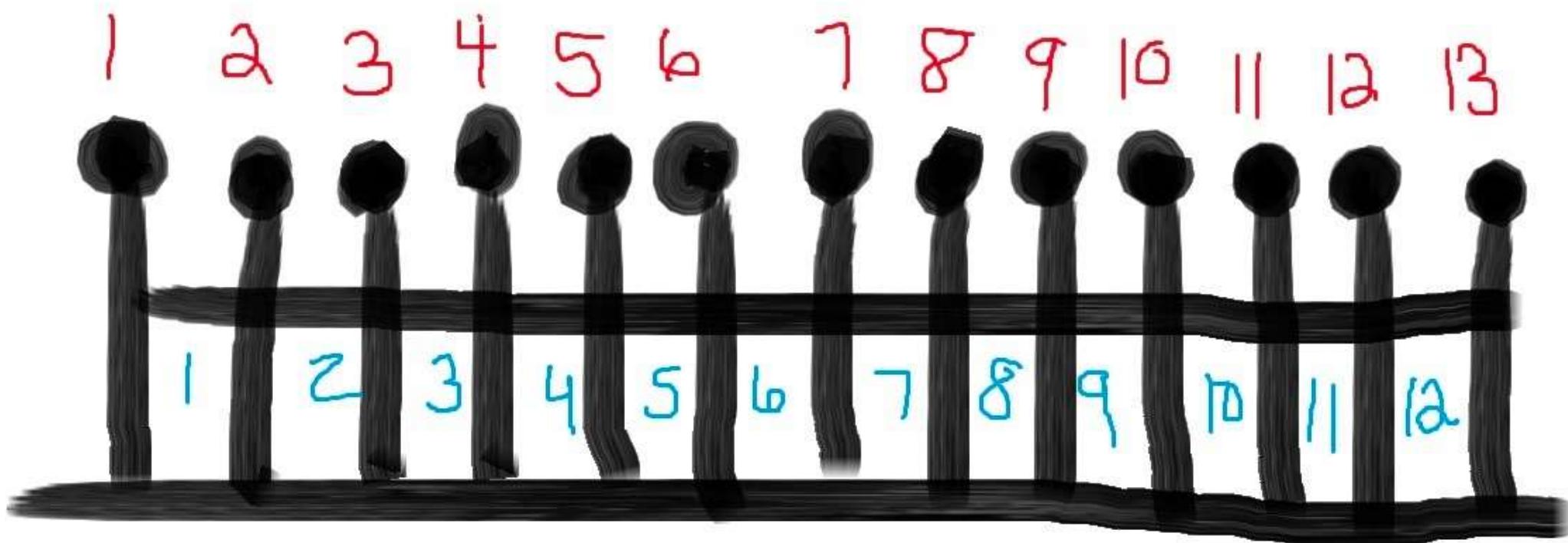
Place Beeper Line

```
def main():
    while front_is_clear():
        put_beeper()
        move()
    put_beeper() # add final put_beeper
```

Fixed!



Fence Post Problem



Also sometimes called an “Off By One Error”



A program executes one line at a time.

The **while** loop checks its condition only at the start of the code block and before repeating.



Which Loop

Repeat
Process

Know how
many times
(definite loop)

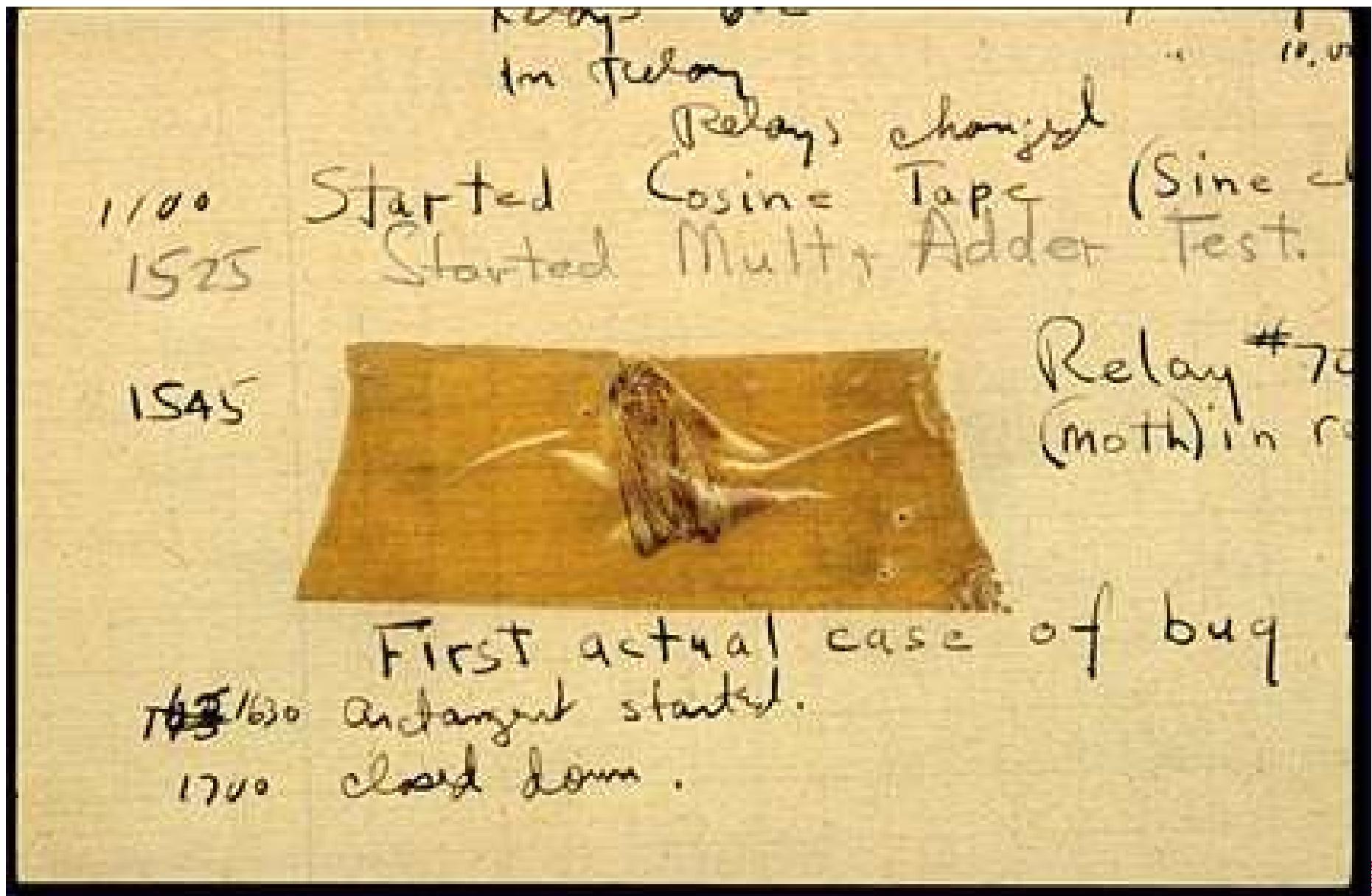
`for` Loop

Don't know how
many times
(indefinite loop)

`while` Loop



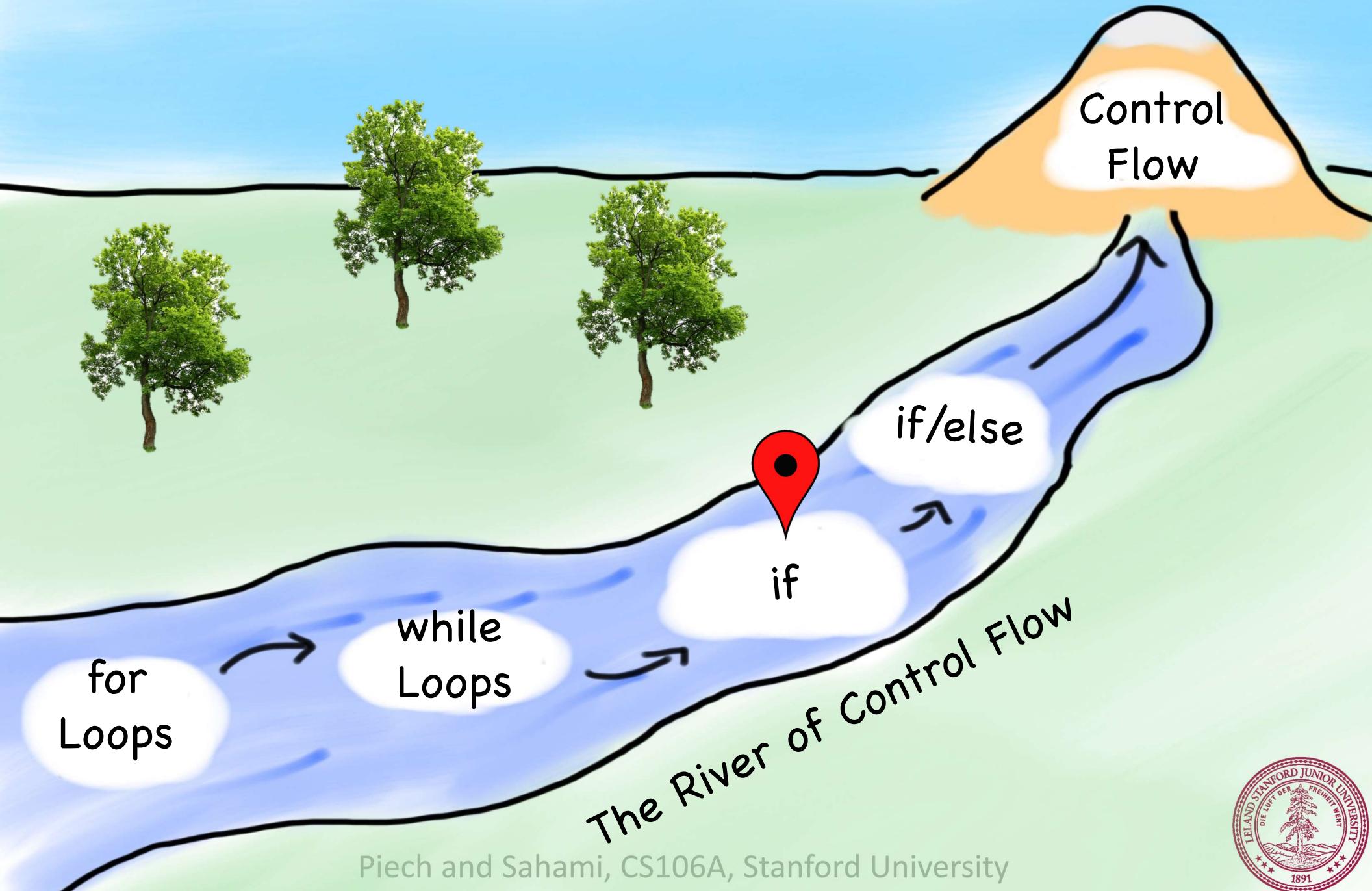
Actual Bug from Marc II



Grace Hopper



Today's Route

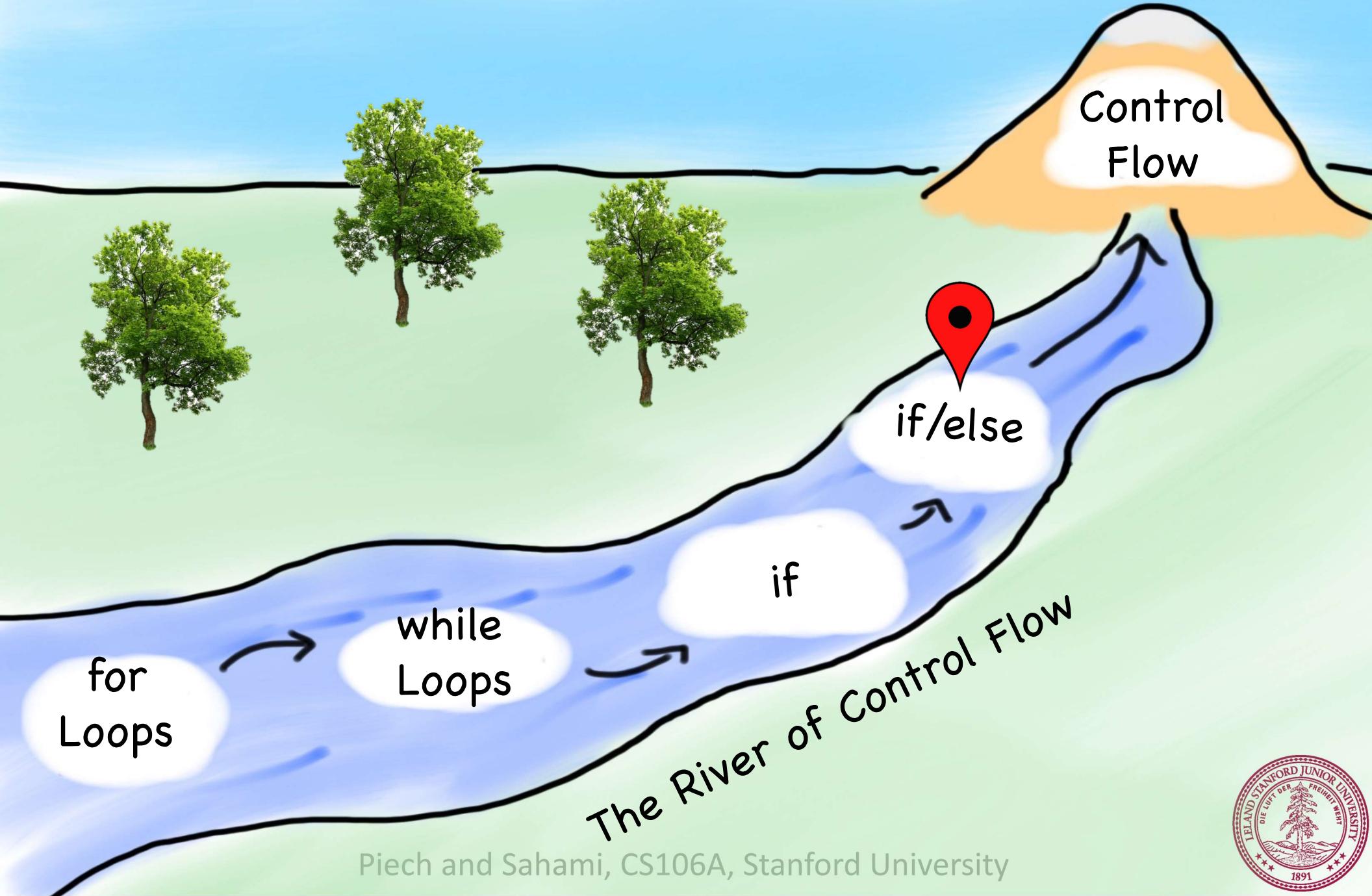


if statement

```
if condition:  
    statements # note indenting
```

```
def safe_pick_up():  
    if beepers_present():  
        pick_beeper() # note indenting
```

Today's Route



if-else statement

```
if condition:  
    statements          # note indenting  
else:  
    statements          # note indenting
```

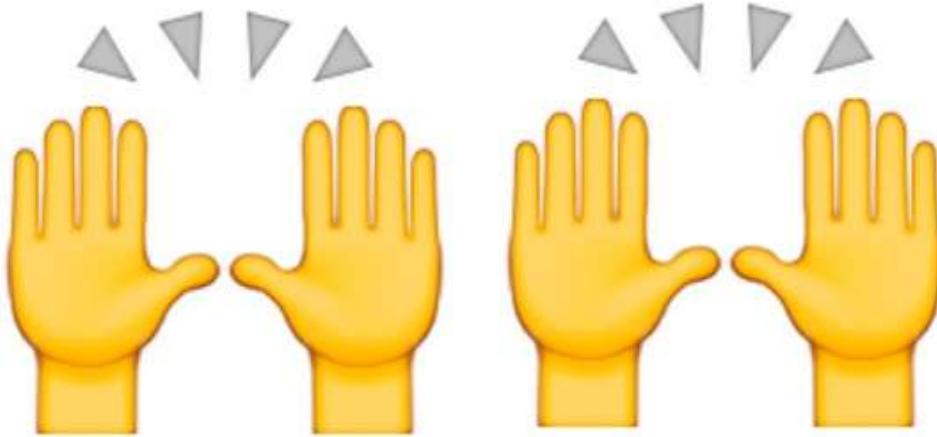
```
def invert_beeper():  
    if beepers_present():  
        pick_beeper() # note indenting  
    else:  
        put_beeper()  # note indenting
```

You just learned most of
programming “control flow”

Today's Goal

1. Code using loops and conditions
2. Trace programs that use loops and conditions



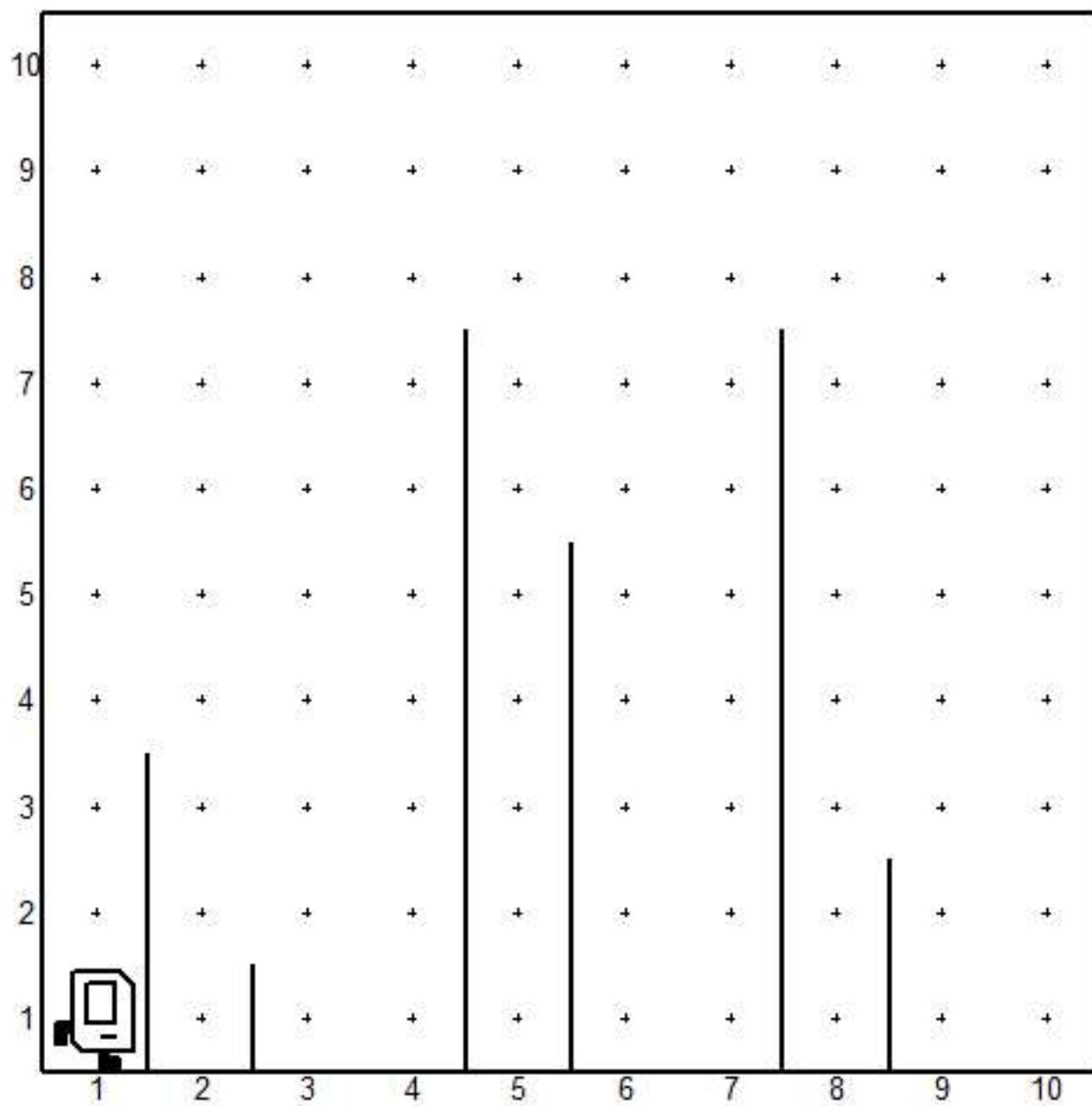


Piech and Sahami, CS106A, Stanford University



Putting it all together
SteepChaseKarel.py

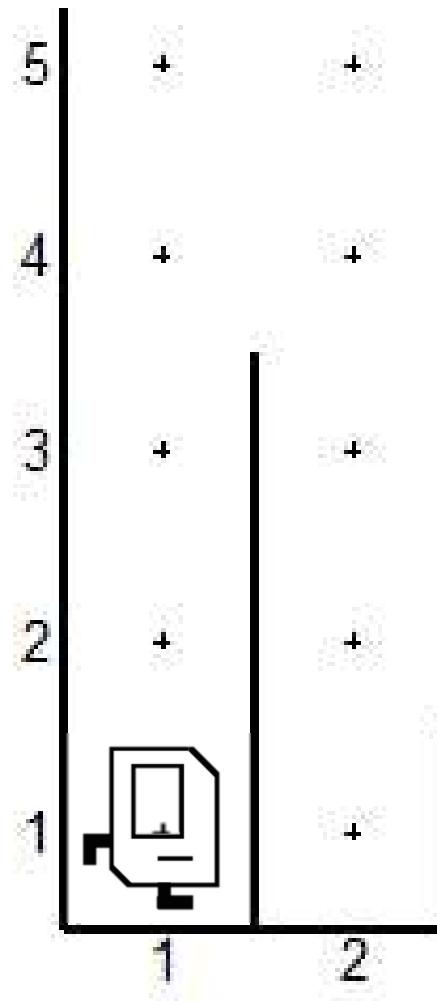
Steeple Chase



Piech and Sahami, CS106A, Stanford University

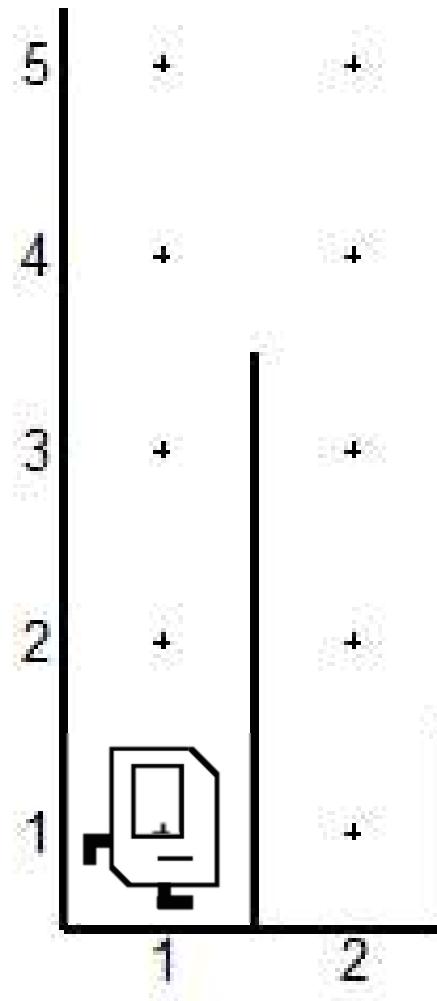


Focus on One Steeple



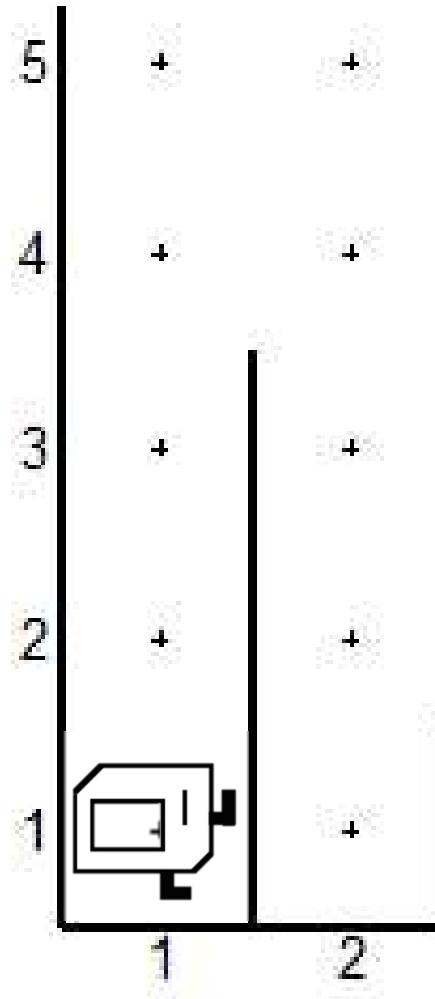
Focus on One Steeple

`turn_left()`



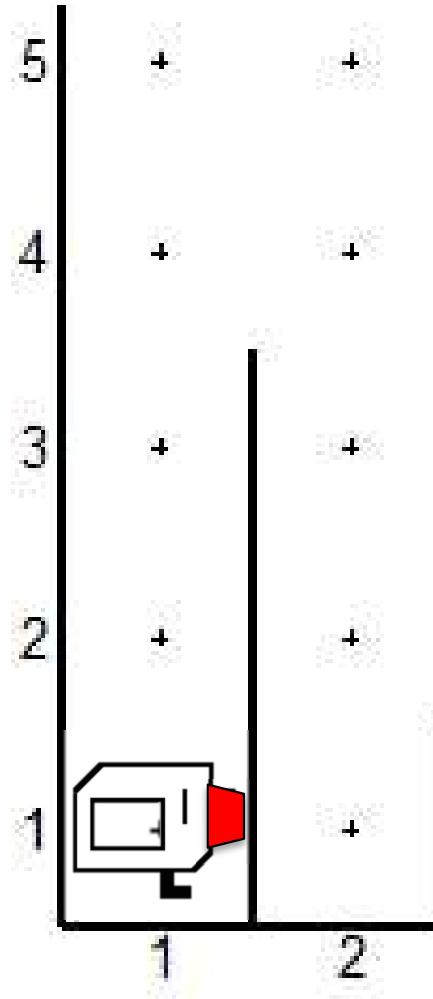
Focus on One Steeple

turn_left()



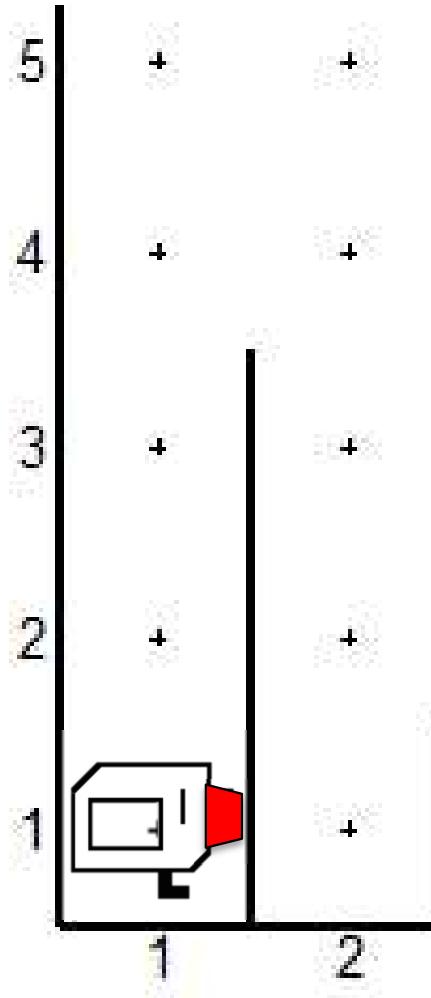
Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()
```



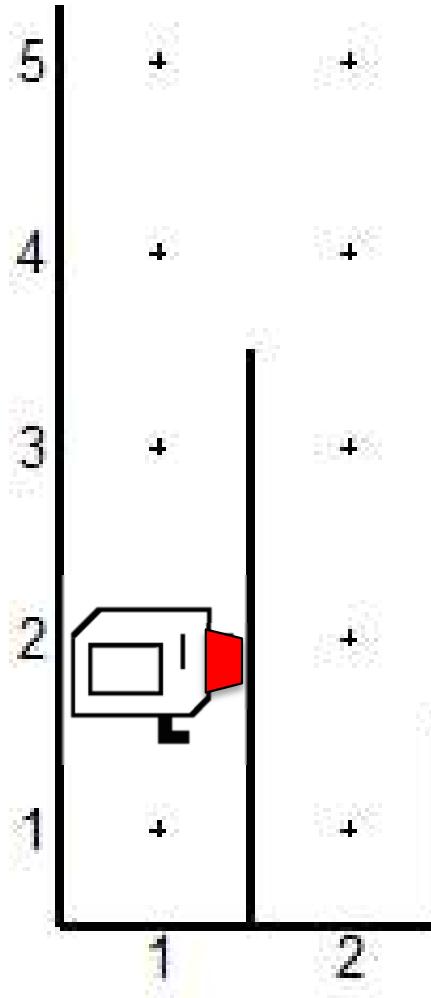
Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()
```



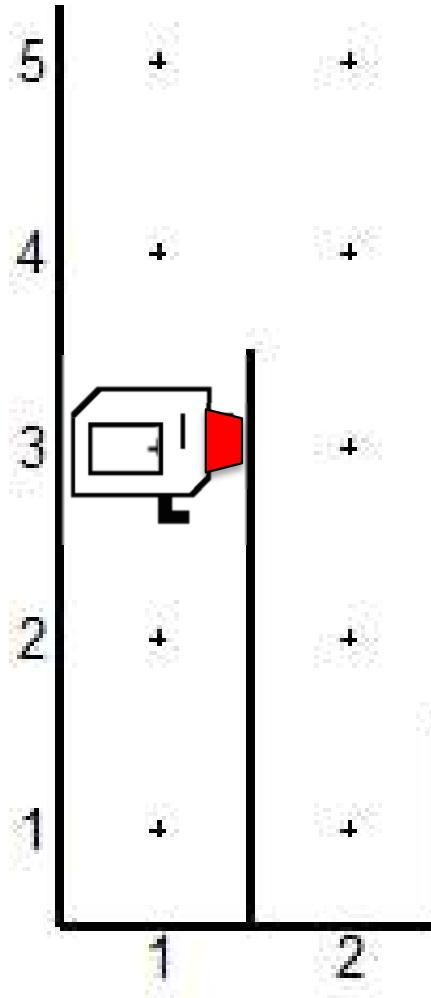
Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()
```



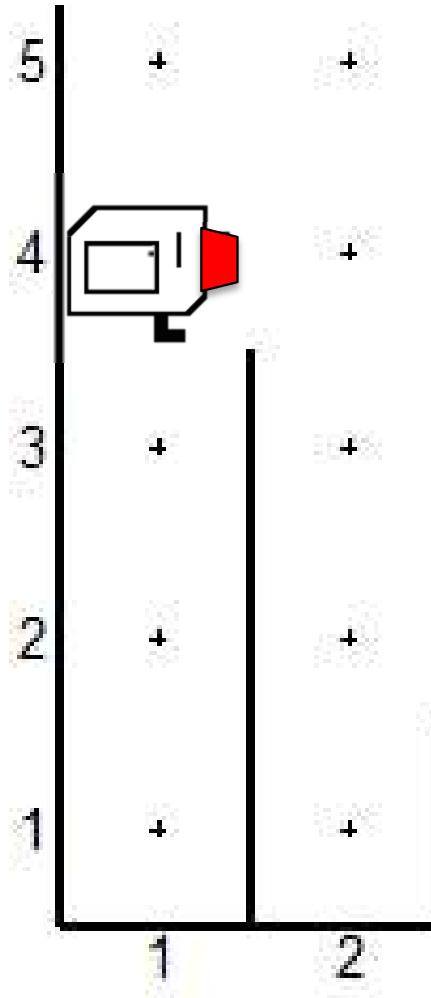
Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()
```



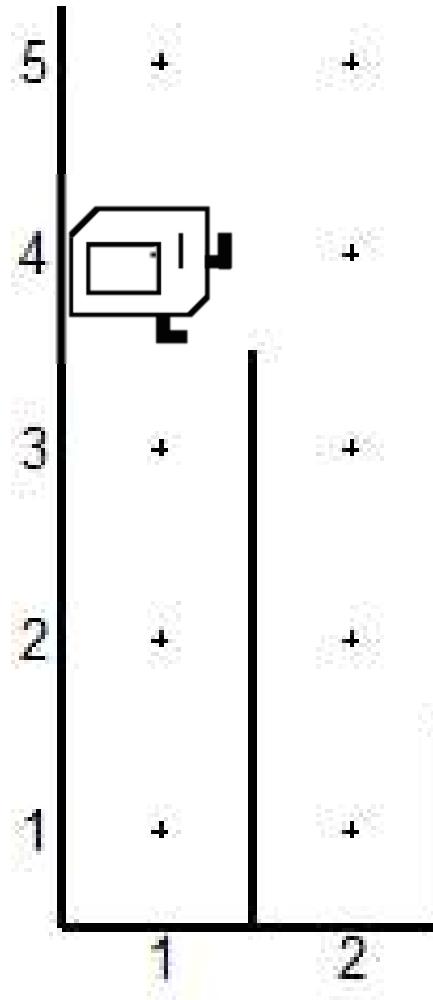
Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()
```

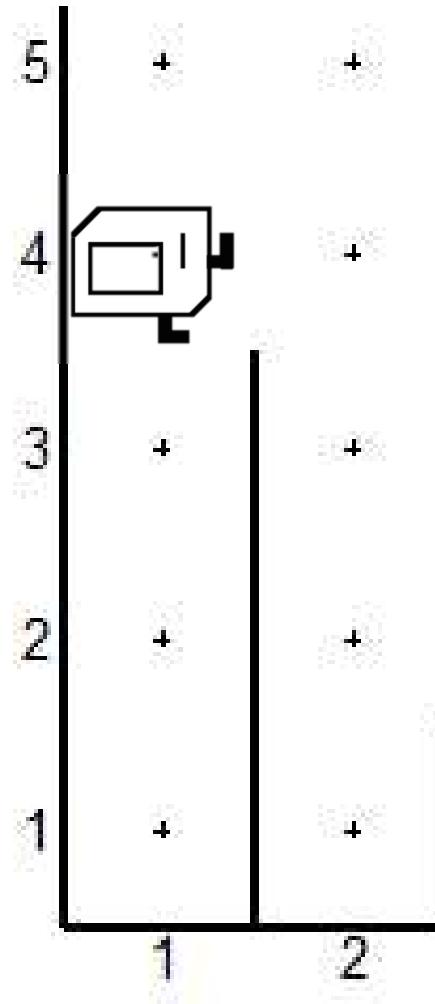


Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()
```



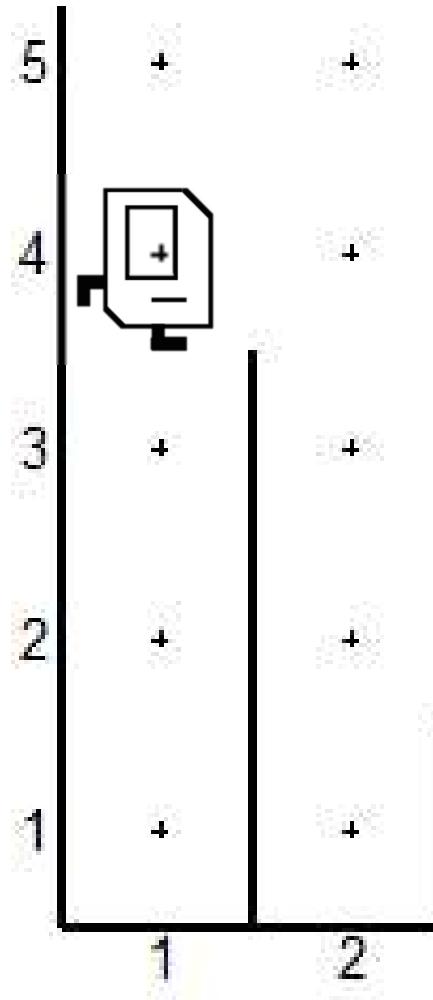
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
    turn_right()
```



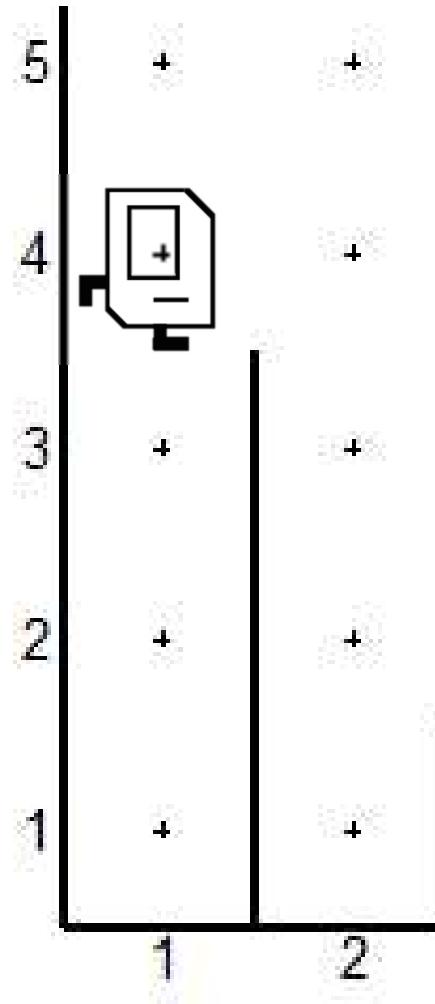
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
    turn_right()
```



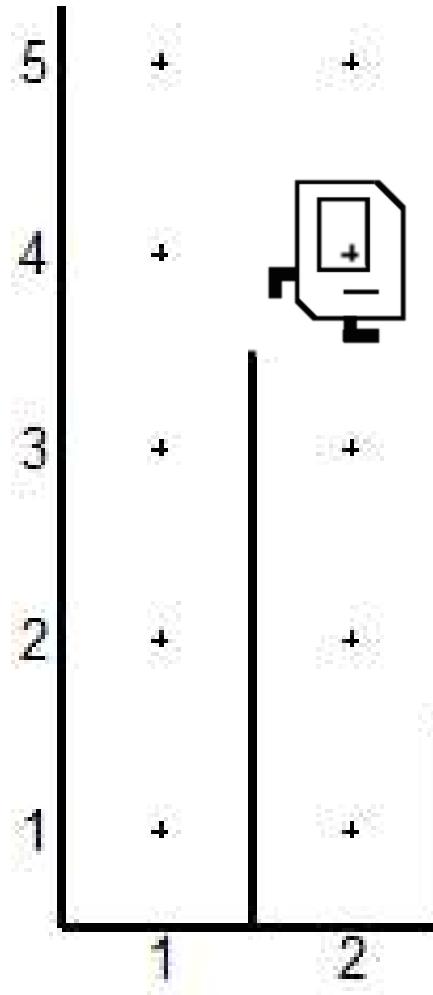
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()
```



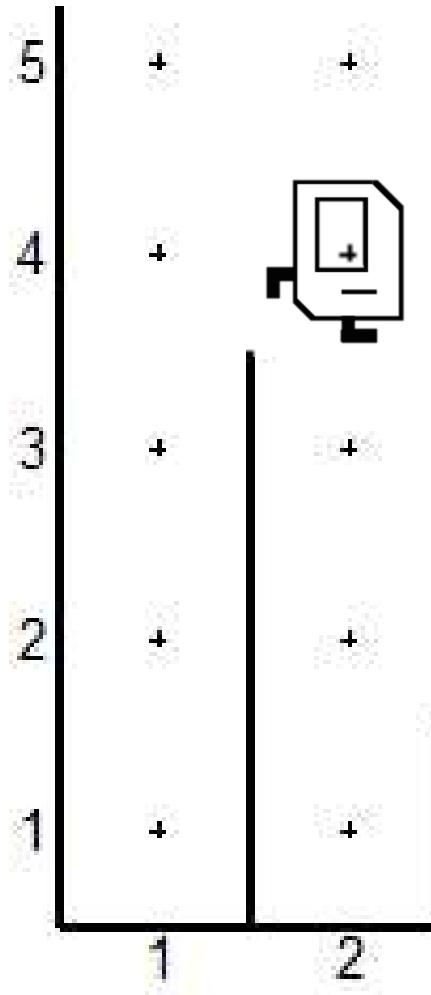
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
    turn_right()  
    move()
```



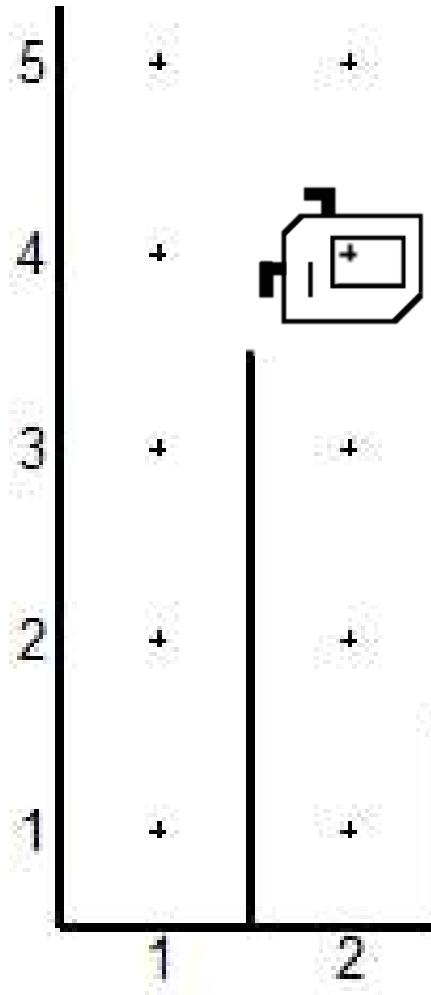
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()
```



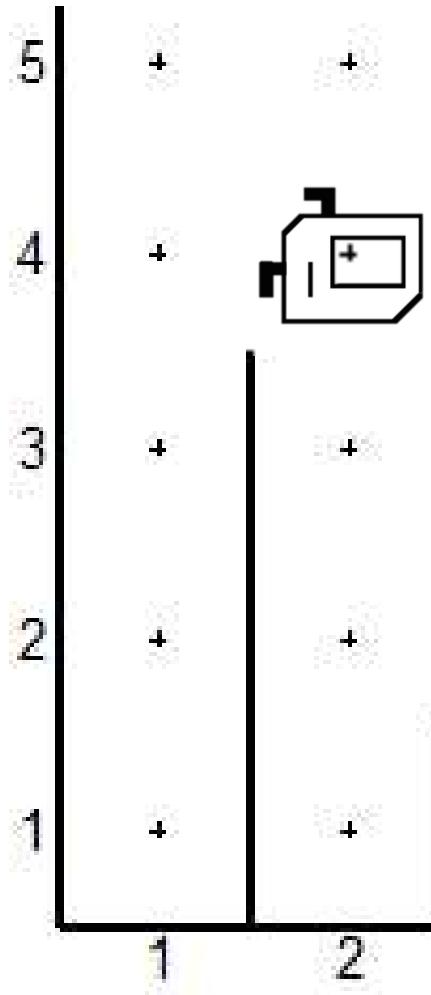
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
    turn_right()  
move()  
turn_right()
```



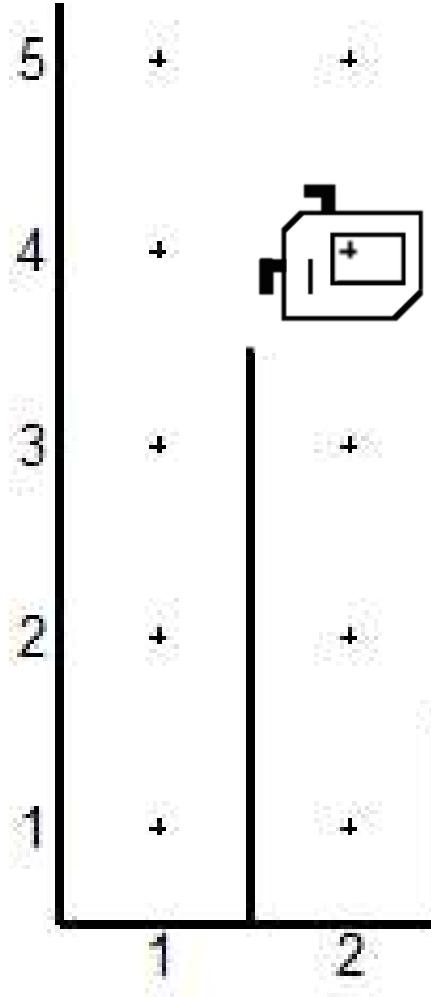
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()
```



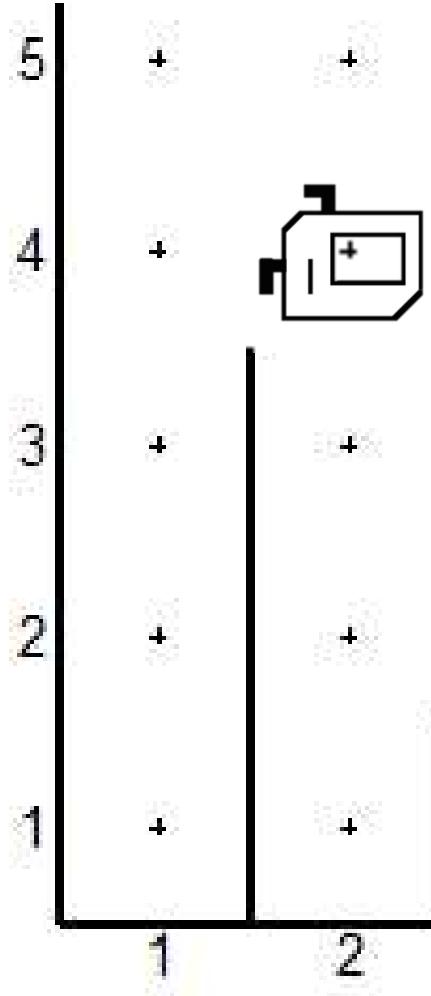
Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()  
  
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple

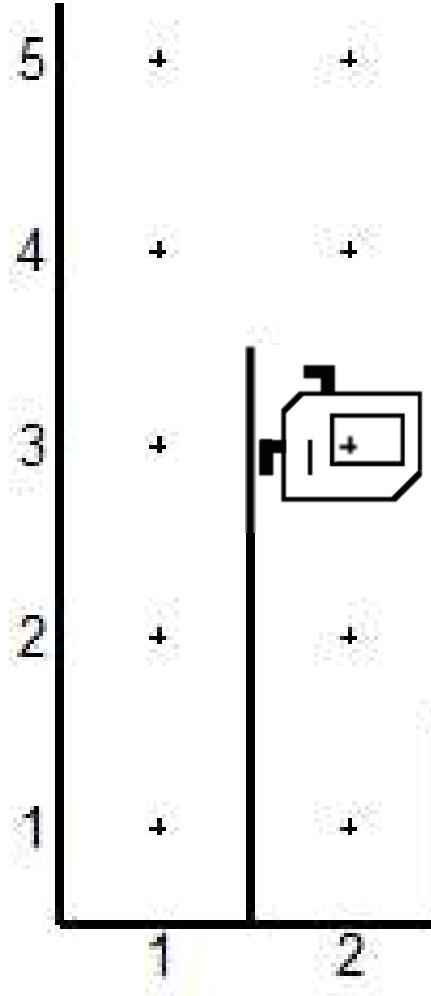


```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()
```

```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple

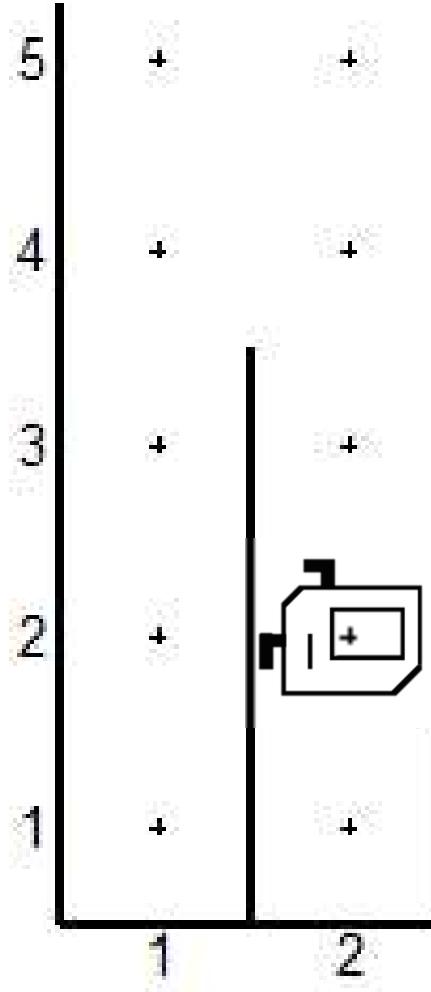


```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()
```

```
def move_to_wall():  
    while front_is_clear():  
        move()
```

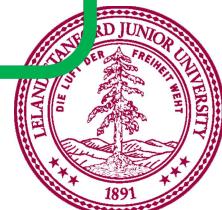


Focus on One Steeple

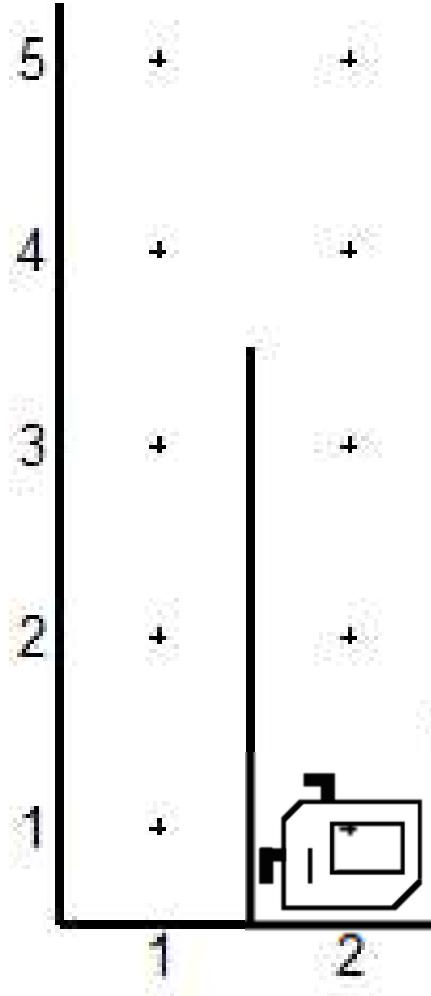


```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()
```

```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple



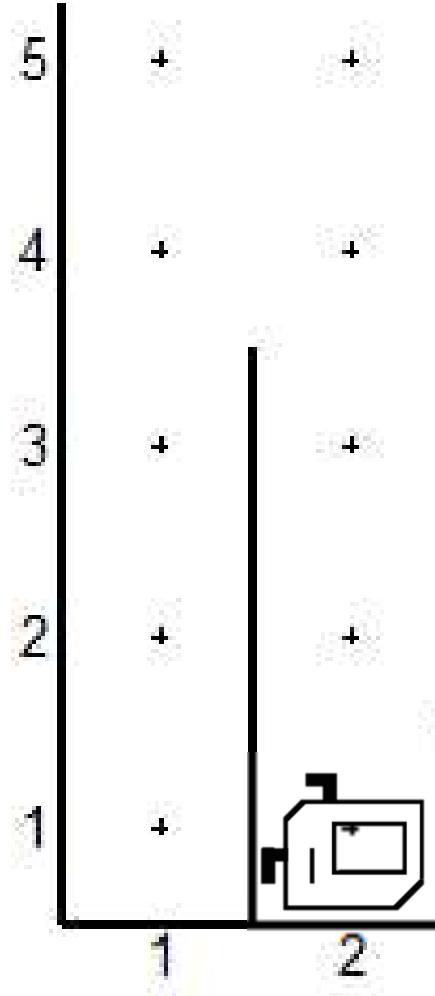
```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()
```

```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple

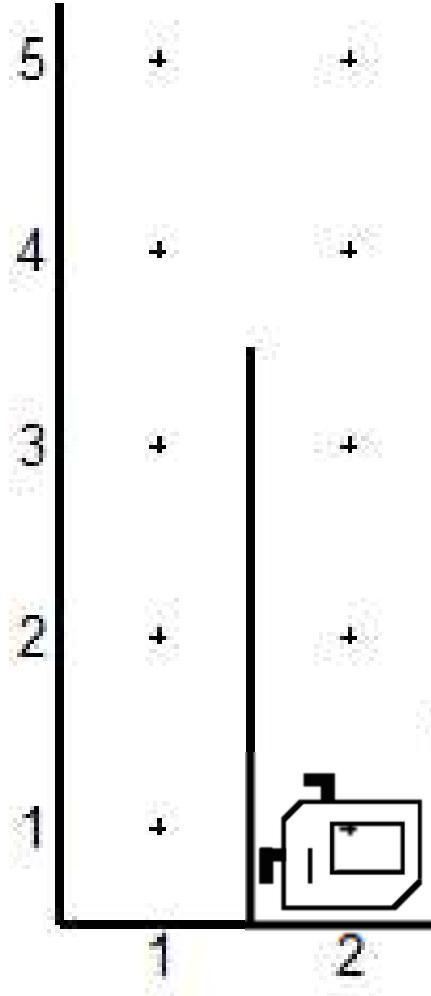
```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()
```



```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple

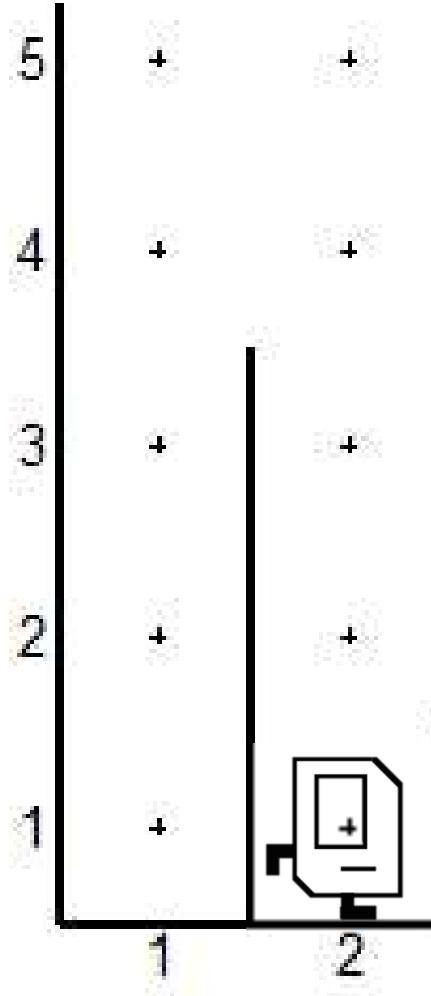


```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()  
turn_left()
```

```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple

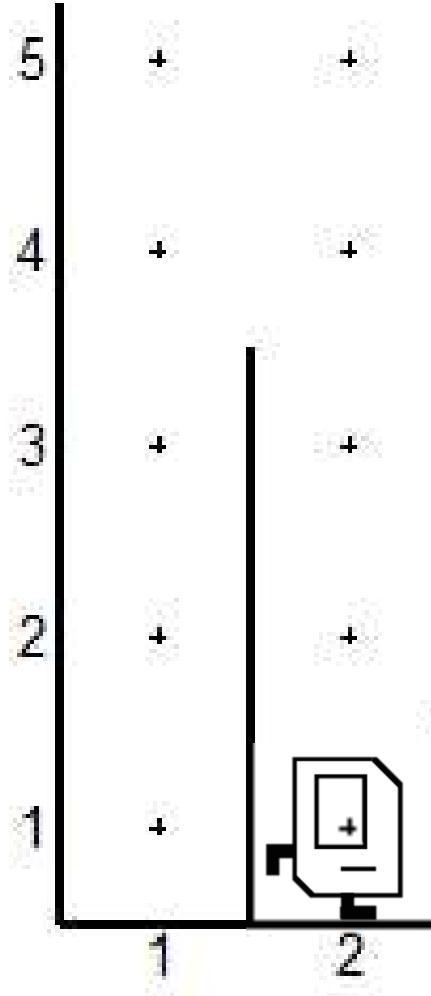


```
turn_left()  
while right_is_blocked():  
    move()  
    turn_right()  
    move()  
    turn_right()  
    move_to_wall()  
    turn_left()
```

```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple



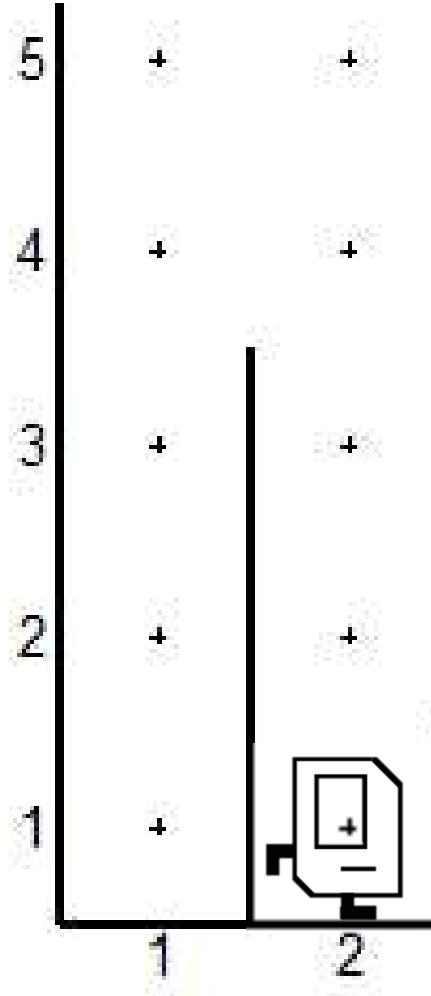
```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()  
turn_left()
```

You need the
postcondition of
a loop to match
the **precondition**

```
def move_to_wall():  
    while front_is_clear():  
        move()
```



Focus on One Steeple



```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()  
turn_left()
```

ascend_hurdle()
descend_hurdle()



Focus on One Steeple

```
turn_left()  
while right_is_blocked():  
    move()  
turn_right()  
move()  
turn_right()  
move_to_wall()  
turn_left()
```

ascend_hurdle()

descend_hurdle()



Focus on One Steeple

```
def ascend_hurdle():
    turn_left()
    while right_is_blocked():
        move()
    turn_right()
    ascend_hurdle()
    move()
    turn_right()
    move_to_wall()
    turn_left()
```

descend_hurdle()



Focus on One Steeple

```
def ascend_hurdle():
    turn_left()
    while right_is_blocked():
        move()
    turn_right()

def descend_hurdle():
    turn_right()
    move_to_wall()
    turn_left()
```

ascend_hurdle()
move()
descend_hurdle()



Focus on One Steeple

```
def ascend_hurdle():
    turn_left()
    while right_is_blocked():
        move()
    turn_right()

def descend_hurdle():
    turn_right()
    move_to_wall()
    turn_left()

def jump_hurdle():
    ascend_hurdle()
    move()
    descend_hurdle()
```



A Whole Program:
SteepChaseKarel.py