

Art of Problem Solving

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First, a cool program

Today's Goal

1. Decomposition: Be able to approach a problem “top down”
2. Stepwise Refinement: Balance testing while decomposing



Quick review

Karel the Robot

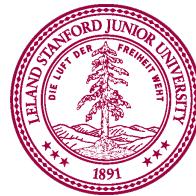


Functions

```
def main():
    go_to_moon()
```

```
def go_to_moon():
    build_spaceship()
    # a few more steps
```

```
def build_spaceship():
    # todo
    put_beeper()
```



For Loops

```
def main():

    # repeats the body 99 times
    for i in range(99):
        # the "body"
        put_beeper()
```



While Loops

```
def main():

    # while condition holds runs body
    # checks condition after body completes
    while front_is_clear():
        move()
```



If Statement

```
def main():

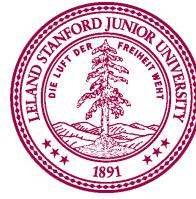
    # If the condition holds, runs body
    if front_is_clear():
        move()
```



If / Else Statement

```
def main():

    # If the condition holds,
    if beepers_present():
        # do this
        pick_beeper()
    else:
        # otherwise, do this
        put_beeper()
```



Code in Place

codeinplace.stanford.edu/public/ide/a/warmup

IDE | Warmup

Docs

Karel

A cheat-sheet with the structure of the Karel programming language. See the [Karel Reader](#) for more details:

Base Karel commands

```
move()
turn_left()
put_beeper()
pick_beeper()
```

Karel program structures

This is the structure of a Karel program

```
from karel.stanfordkarel import *

# Comments can be included in any part
# of a program. They start with a #
# and include the rest of the line.
# the computer will ignore them, but they
# are very helpful for human readers!

def main():
    # code to execute

    # declarations of other functions

    # necessary boilerplate to start execution
if __name__ == '__main__':
    main()

# example program to move, put_beeper, move
def main():
    move()
    put_beeper()
    move()
```

main.py

```
1 from karel.stanfordkarel import *
2
3 # File: warmup.py
4 #
5 # -----
5 # The warmup program defines a "main"
6 # function which currently just has one
7 # Command. Add two more commands to make karel: move(),
8 # pick_beeper(), move()
9 def main():
10     move()
11     pick_beeper()
12     move()
13
14
15
16
17
18 # don't edit these next two lines
19 # they tell python to run your main function
20 if __name__ == '__main__':
21     main()
```

World >

World: Warmup

Terminal

```
%
```



Code in Place

codeinplace.stanford.edu/public/ide/a/warmup

IDE | Warmup

Docs Karel

Conditions:

```

if condition:
    # code run if condition passes

if condition:
    # code block for "yes"
else:
    #code block for "no"

# example: a safe move
if front_is_clear():
    move()

```

For Loop:

```

for i in range(count):
    # code to repeat

# example: place 100 beepers
for i in range(100):
    put_beeper()

```

While Loop:

```

while condition:
    # code to repeat

```

main.py

```

1 from karel.stanfordkarel import *
2
3 # File: warmup.py
4 #
5 # -----
6 # The warmup program defines a "main"
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```

World >

World: Warmup

Terminal

%



Code in Place

codeinplace.stanford.edu/public/ide/a/warmup

IDE | Warmup

Docs Karel

main.py

```
from karel.stanfordkarel import *
# File: warmup.py
# -----
# The warmup program defines a "main"
# function which currently just has one
# Command. Add two more commands to make karel: move(), move()
# pick_beeper(), move()
def main():
    move()
    pick_beeper()
    move()
# don't edit these next two lines
# they tell python to run your main function
if __name__ == '__main__':
    main()
```

World >

World: Warmup

Names of the conditions

```
# karel conditions
front_is_clear()
beepers_present()
beepers_in_bag()
left_is_clear()
right_is_clear()
facing_north()
facing_south()
facing_east()
facing_west()

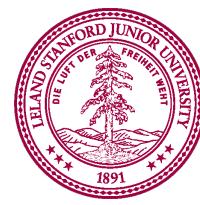
# opposites
front_is_blocked()
no_beeper_present()
no_beeper_in_bag()
left_is_blocked()
right_is_blocked()
not_facing_north()
not_facing_south()
not_facing_east()
not_facing_west()
```

Additional commands:

For advanced Karel programs you can use these two secret commands

random(p)
paint_corner(color)

Terminal %



End review

```
def art_of_problem_solving():
    # lesson plan
    decomposition()
    mountain_karel()
    rhoomba_karel()
    if extra_time():
        word_search_karel()
```

```
def art_of_problem_solving():
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```

Make Pasta from Scratch



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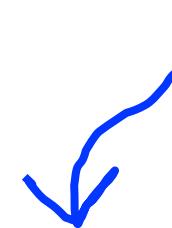


Make Pasta from Scratch





My helper is a 3 year old.
Like Karel, needs very clear
instructions



We are going to
need to decompose
the task

Make Pasta from Scratch

make_dough()



shape_pasta()



cook_pasta()

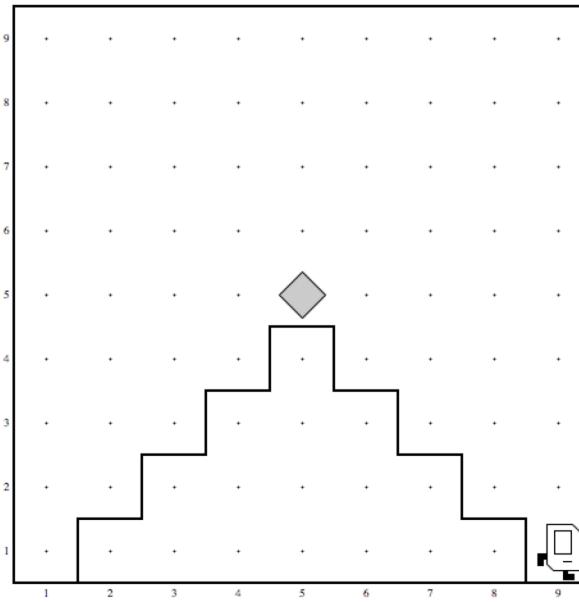
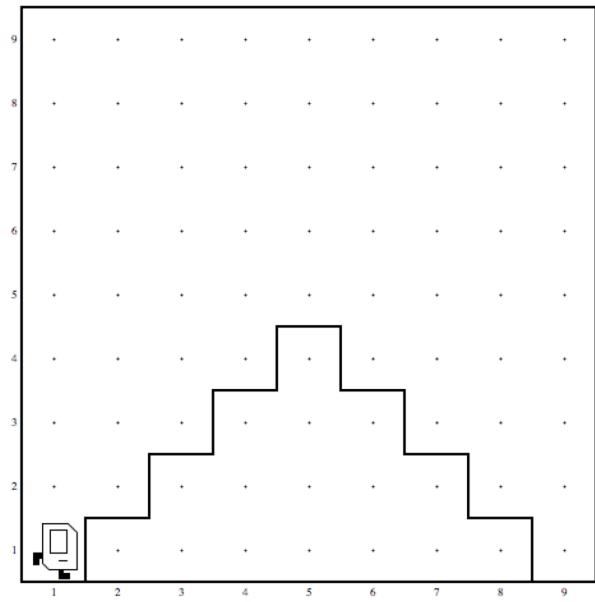


Make Pasta from Scratch

```
1 def main():
2     """
3     This program is meant to show how an everyday
4     task (like cooking) can be approached using
5     the art of stepwise refinement.
6     """
7     make_dough()
8     shape_pasta()
9     cook_pasta()
10
11 def make_dough():
12     # TODO: implement
13     pass
14
15 def shape_pasta():
16     # TODO: implement
17     pass
18
19 def cook_pasta():
20     # TODO: implement
21     pass
```

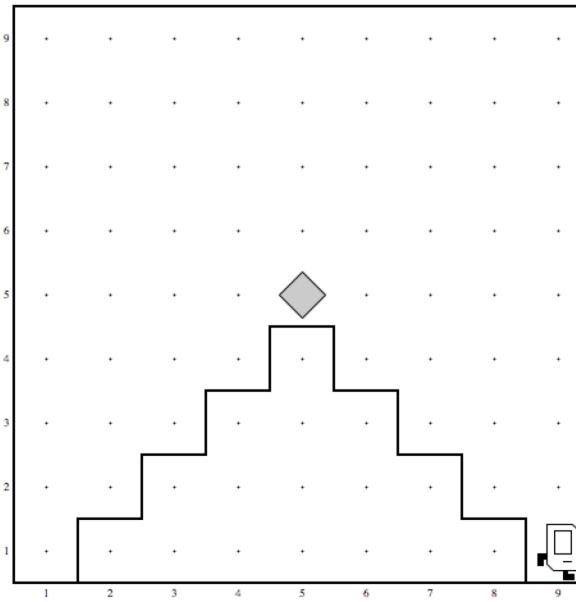
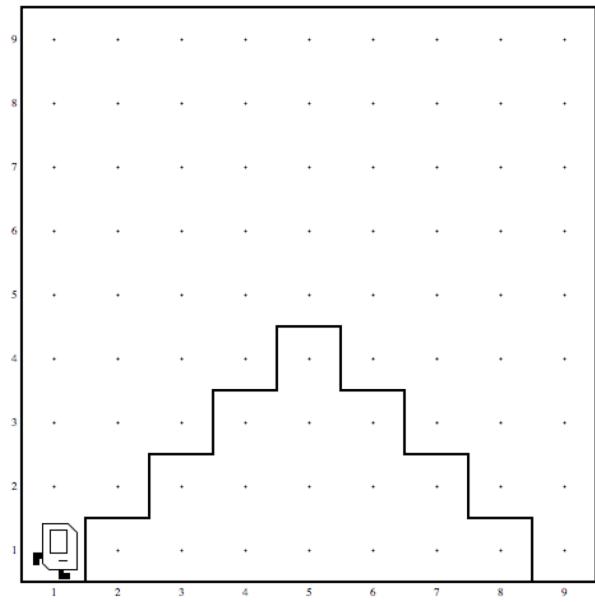


Mountain Karel

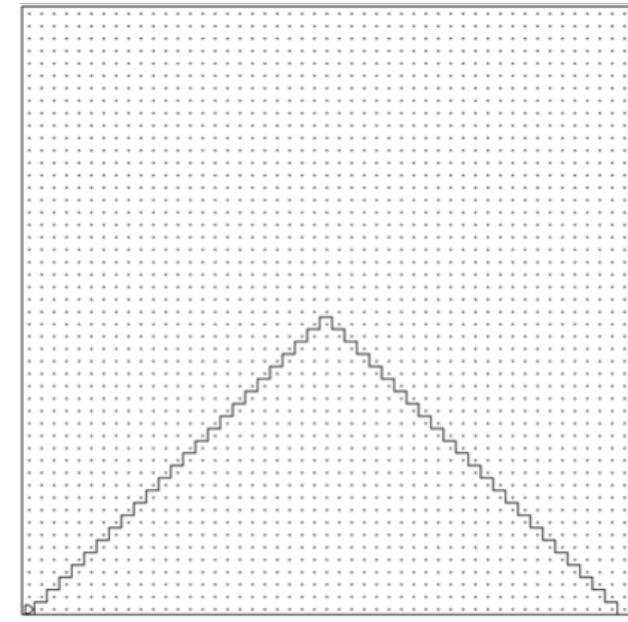
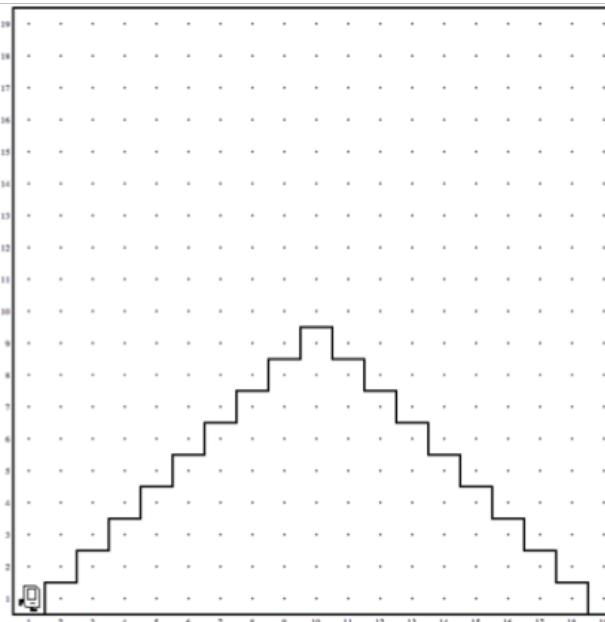
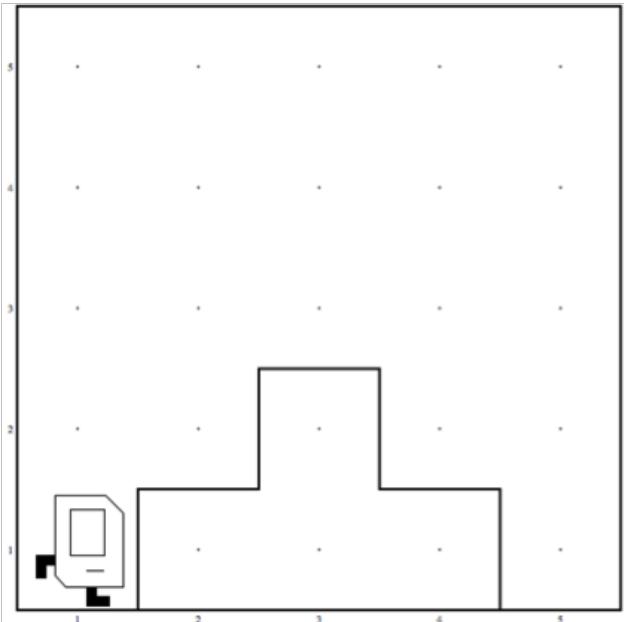


```
def art_of_problem_solving():
    # lesson plan
    decomposition()
    mountain_karel()
    rhoomba_karel()
    if extra_time():
        word_search_karel()
```

Mountain Karel



Mountain Karel



Muhammed ibn
Musa Al Kwarizmi

nd Sahami, CS106A, Stanford University



DO
YOUR
THING

Piech and Sahami, CS106A, Stanford University



Pro Tips



A good function should do “one conceptual thing”



Know what it does by looking at its name



Less than 10 lines, 3 levels of indentation



Reusable and easy to modify

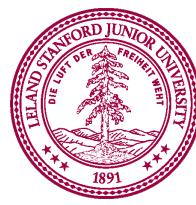


Well commented

There are two types of programs.

One is so complex, there is nothing obvious wrong with it.

One is so clear, that this obviously nothing wrong with it.



Aside: Common Errors

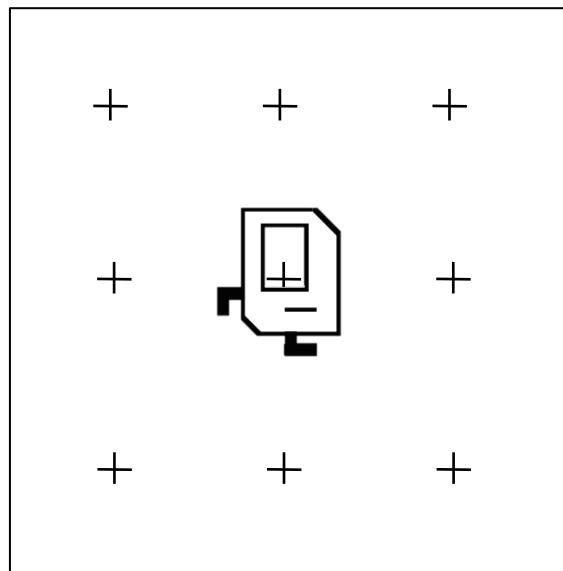
Lather,
Rinse,
Repeat

conditions
ing healthy
ch easier to
oo. You just
hower after
sure you get
only Wella makes
the original Balsam, and it's
great stuff. Wella Balsam.



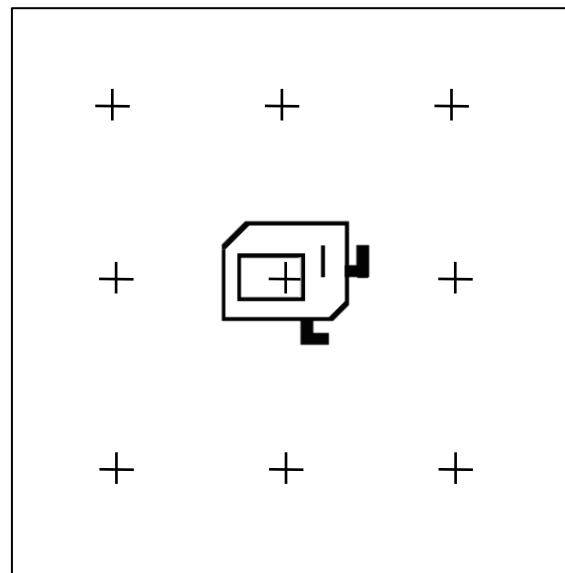
Infinite Loop

```
def turn_to_wall():
    while left_is_clear():
        turn_left()
```



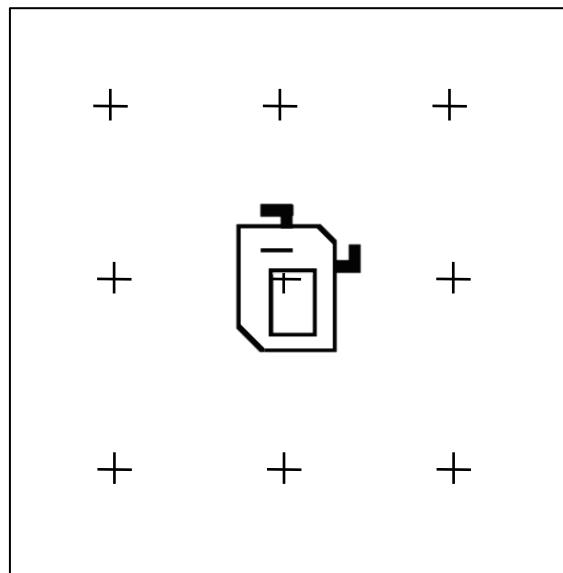
Infinite Loop

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def turn_to_wall():
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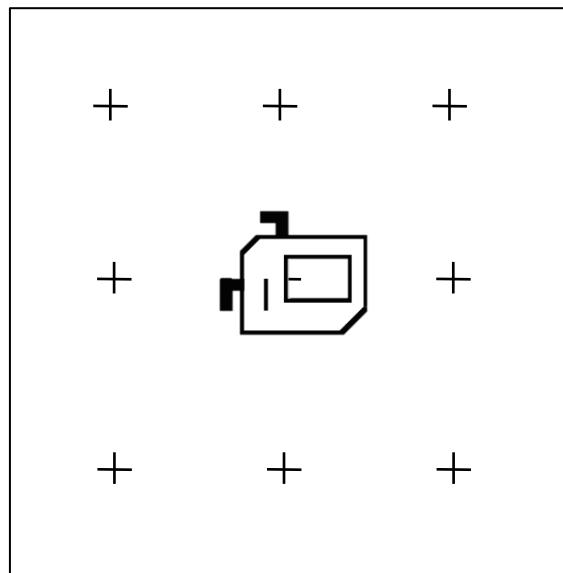
Infinite Loop

```
def turn_to_wall():
    while left_is_clear():
        turn_left()
```



Infinite Loop

```
def turn_to_wall():
    while left_is_clear():
        turn_left()
```



Pre/Post that Don't Match

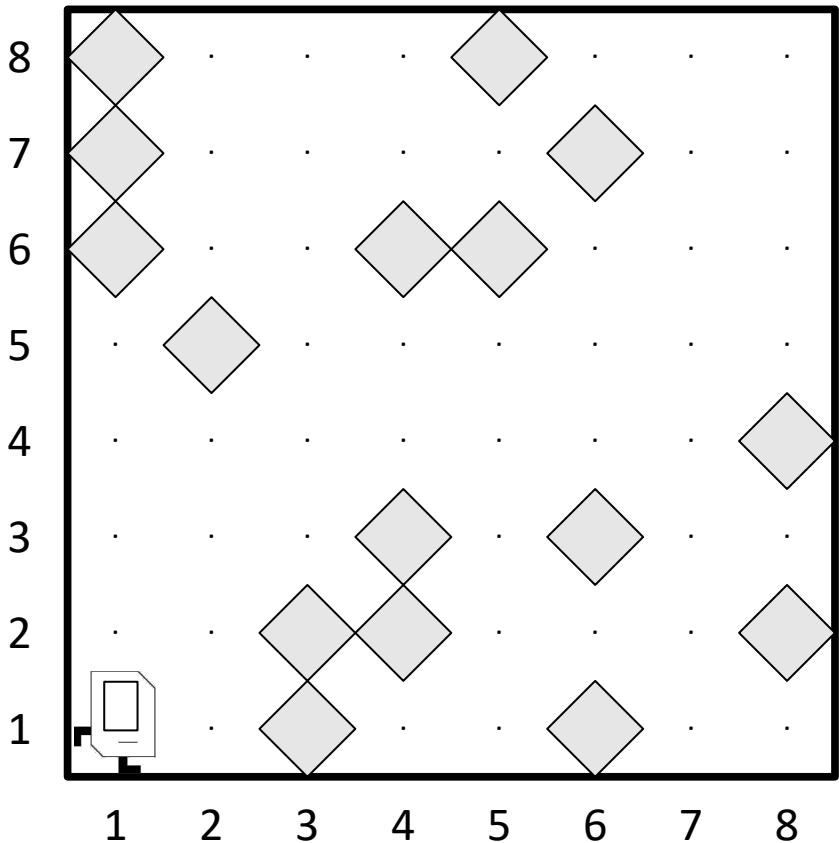
```
def climb_mountain:  
    while front_is_clear():  
        # step up  
        move()  
        turn_left()  
        move()
```

What do you assume here?

Does the end condition of the loop match the start assumptions?



Rhoomba Karel



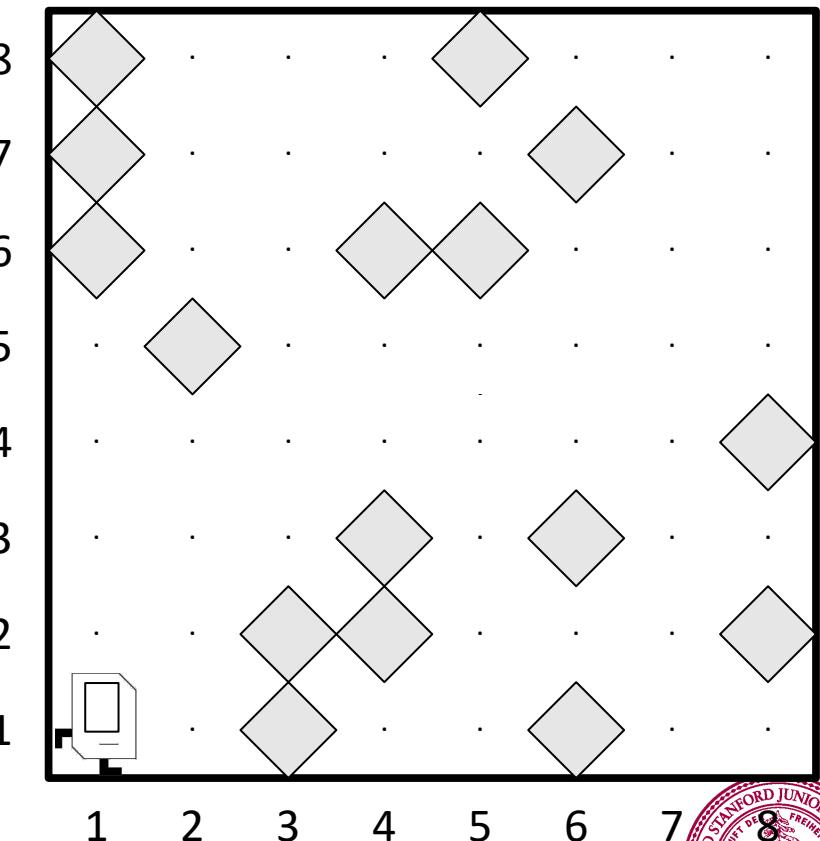
An actual Rhoomba Robot



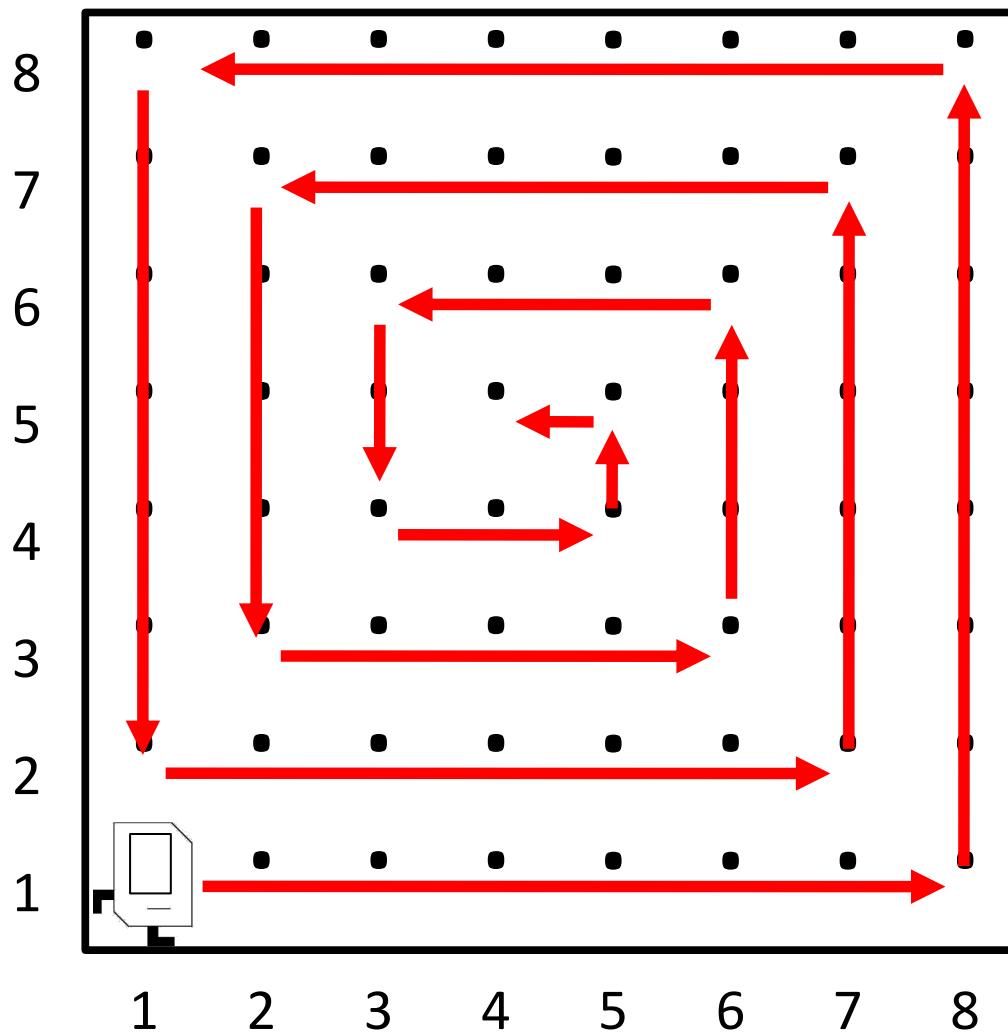
```
def art_of_problem_solving():
    # lesson plan
    decomposition()
    mountain_karel()
    rhoomba_karel()
    if extra_time():
        word_search_karel()
```

Rhoomba Karel

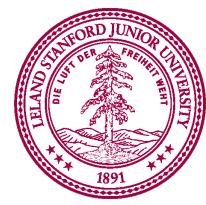
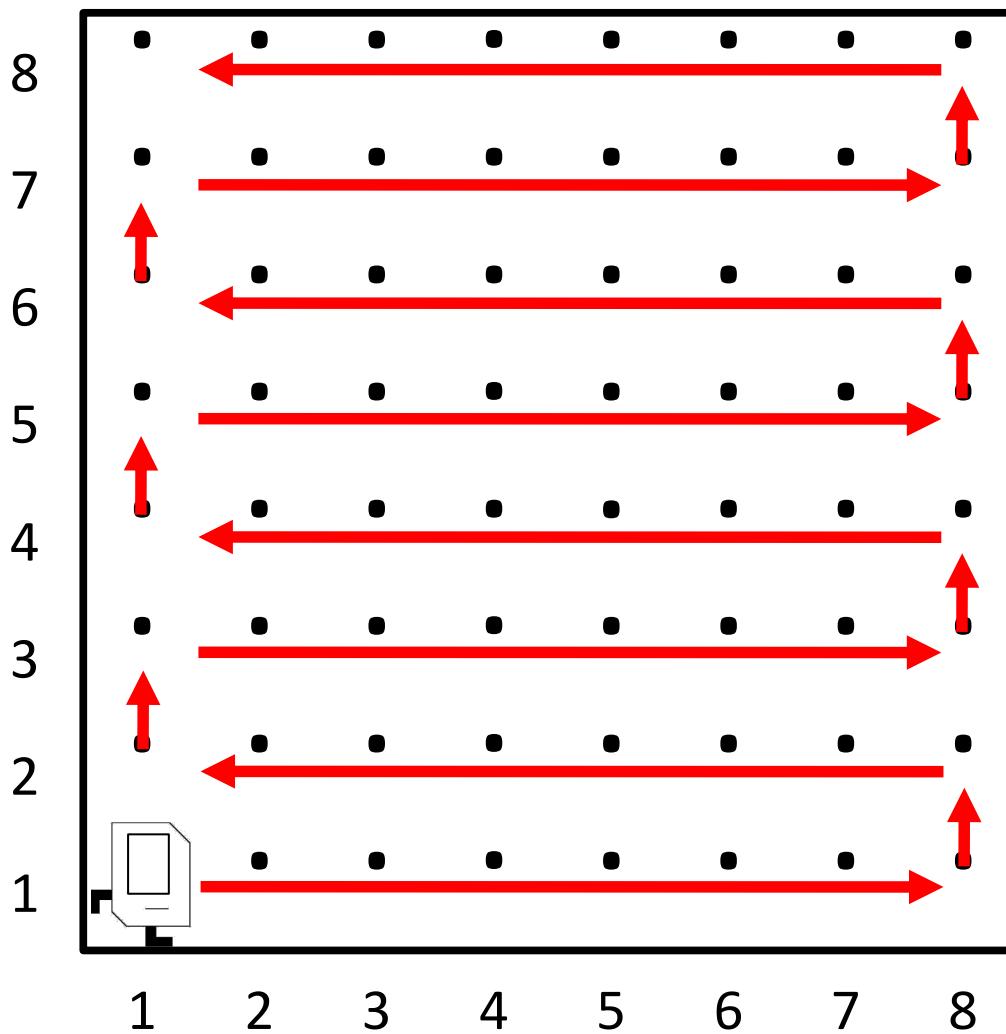
- Write a **Roomba** Karel that sweeps the entire world of all beepers.
 - Karel starts at (1,1) facing East.
 - The world is rectangular, and some squares contain beepers.
 - There are no interior walls.
 - When the program is done, the world should contain 0 beepers.
 - Karel's ending location does not matter.
- How should we approach this tricky problem?



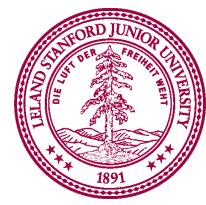
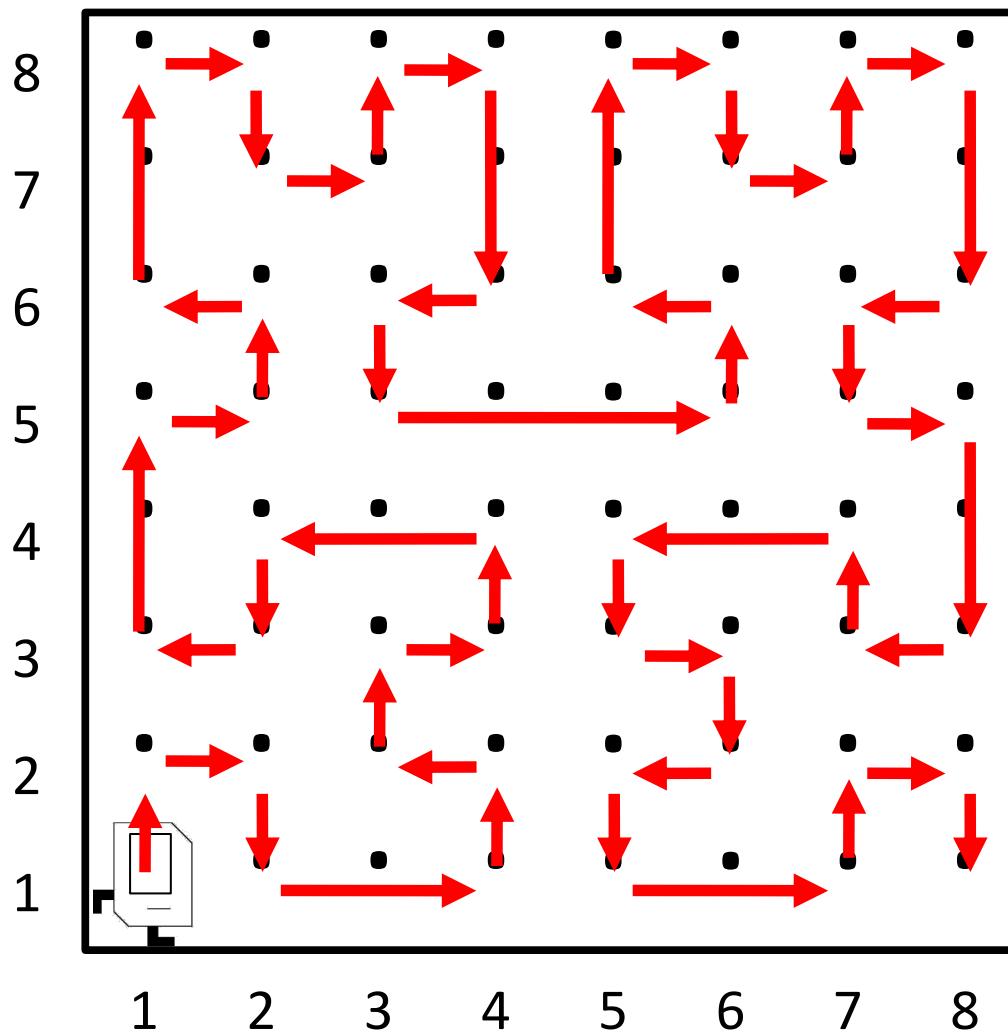
Possible Algorithm 1



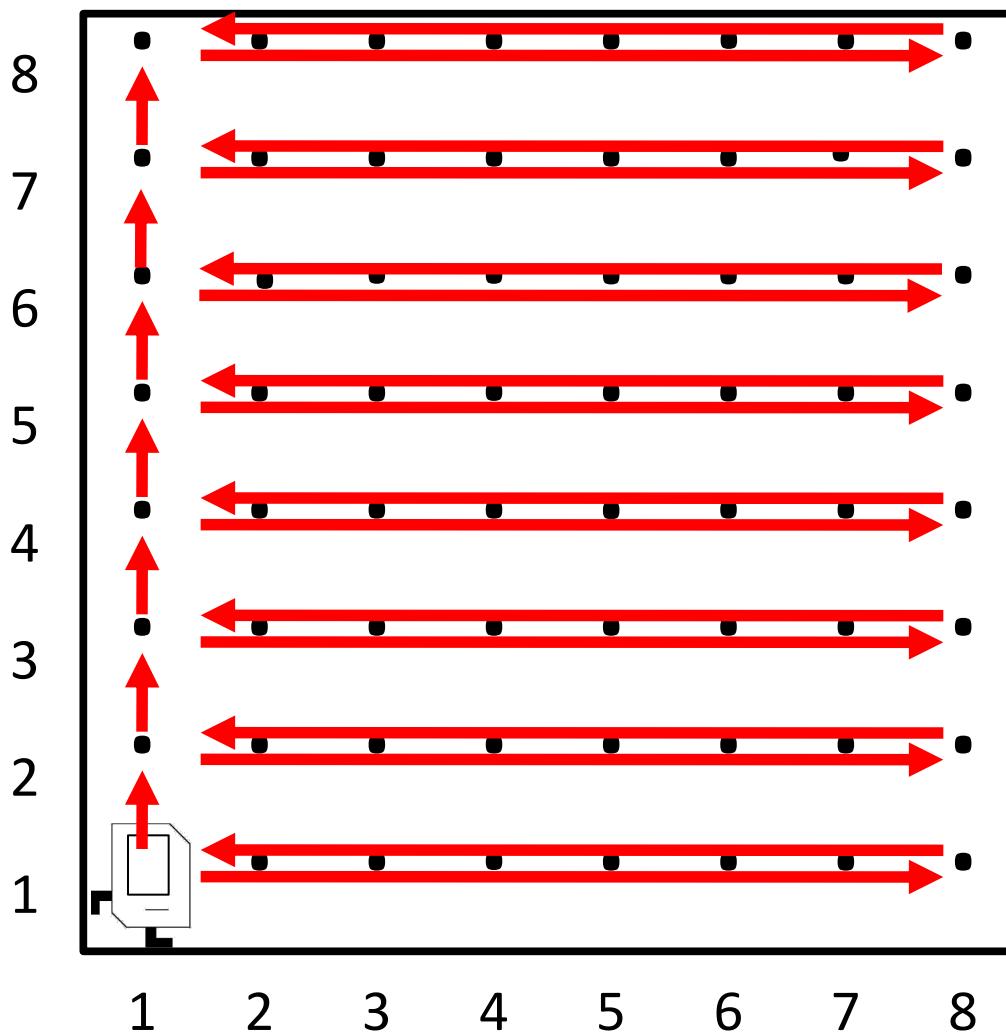
Possible Algorithm 2



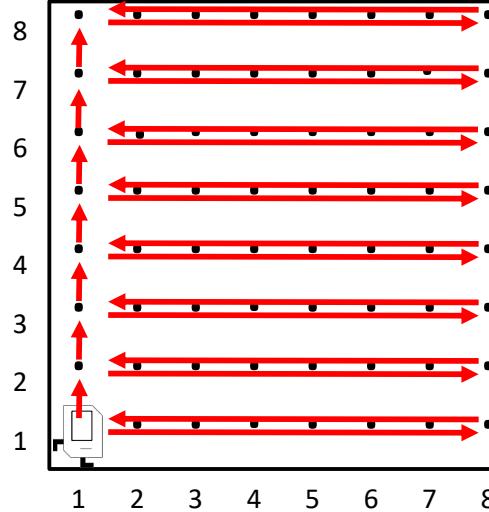
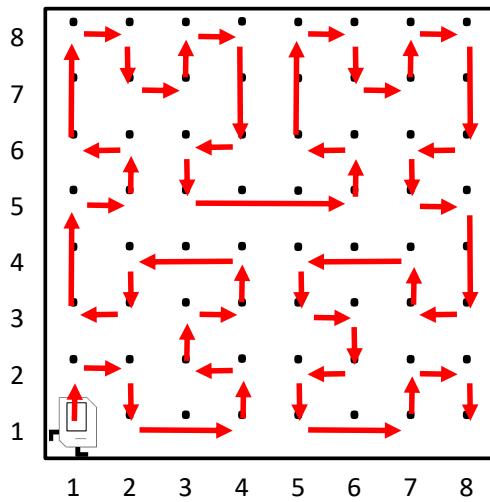
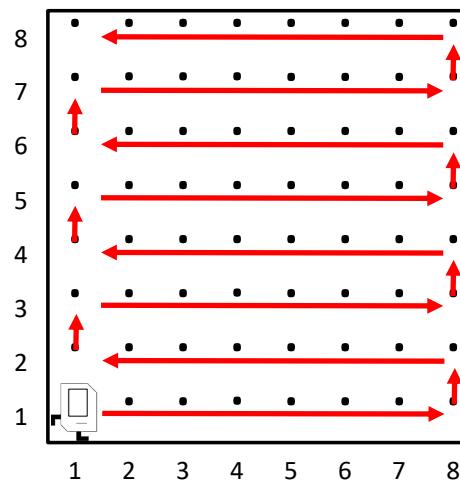
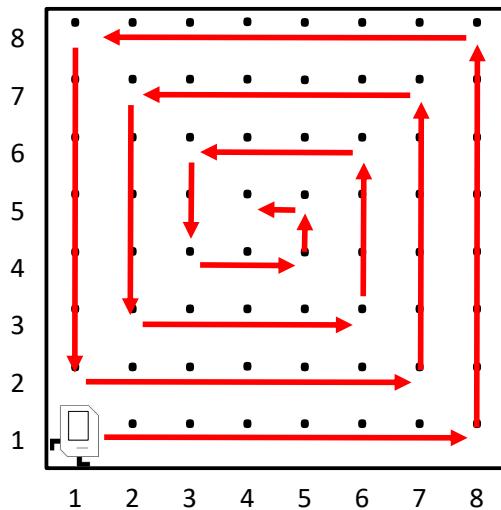
Possible Algorithm 3



Possible Algorithm 4



Which Algorithm???



Rhoomba Karel

RhoombaKarel

Start Program

Reset Program

Load World

New World

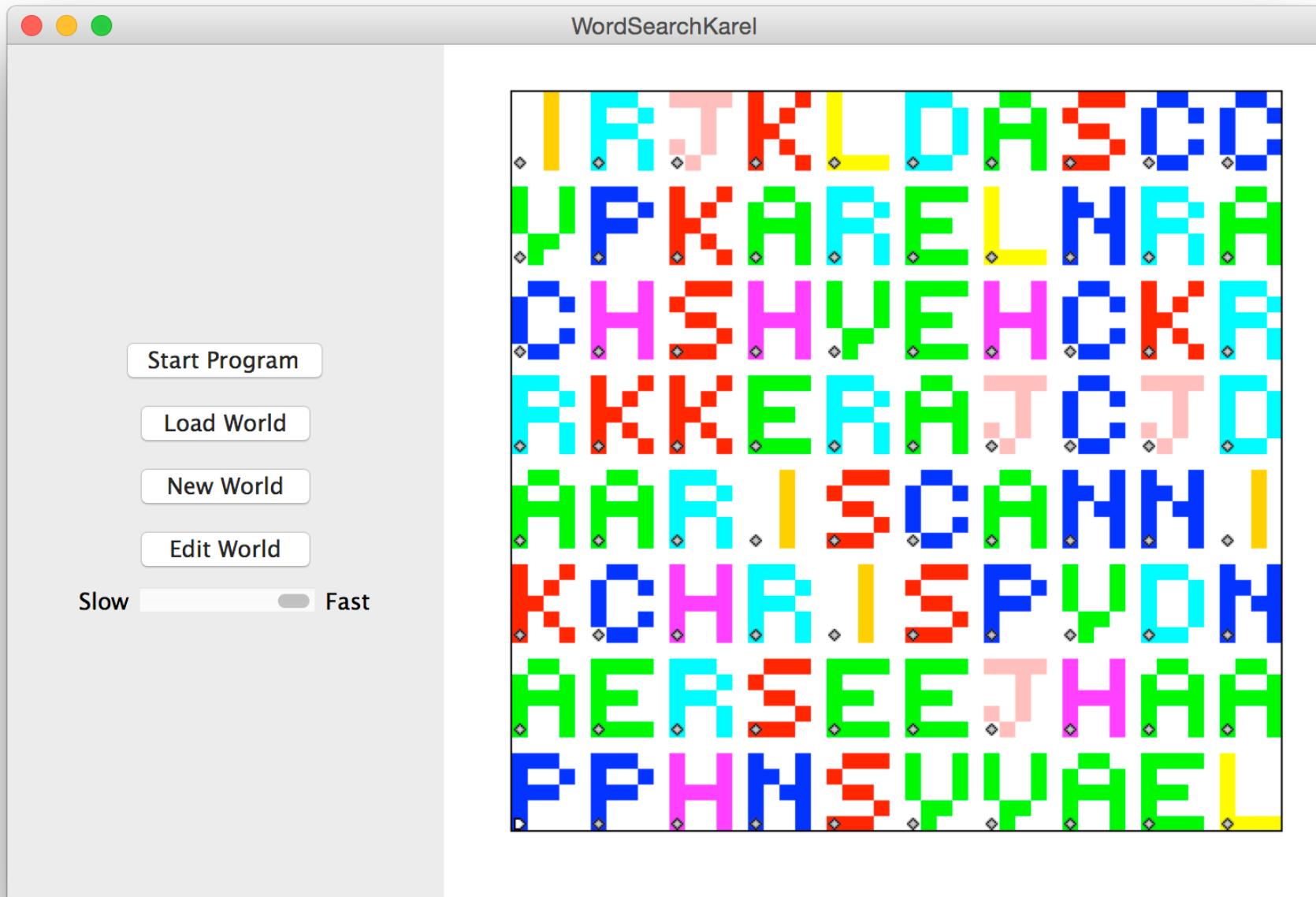
Edit World

Slow Fast

Welcome to Karel!

Column	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8
1	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+
3	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+	+
6	+	+	+	+	+	+	+	+
7	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+





```
def art_of_problem_solving():
    # lesson plan
    decomposition()
    mountain_karel()
    rhoomba_karel()
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```
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