Welcome!

We'll get started shortly. Please take the Zoom poll in the meanwhile!

CS 49 Week 2

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Agenda

- Review of lecture concepts
  - Control Flow: `if`, `if-else`, `for`, `while`
  - Functions
- Worked example: Five Corridors
- Section problem: Hospital Karel

How to get hold of me / get help from other resources

- Surajit's office hours
  - Fridays 12 noon–1p, directly after section
  - By appointment on Zoom
- Pronto DM for a quick response (usually within a couple hours)
- Email bosesurajit@fhda.edu or Canvas inbox, 24 hr turnaround
- The github repo has section materials, starter code, and solutions

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- Pronto DM or Canvas inbox for Lane
- Lane's office hours
- Online or in-person tutoring at the STEM center (Room 4213)

Control Flow: Conditionals, Loops

Control Flow

- The order in which instructions are executed is not always linear
- We discussed how in Move Beeper, calling **`turn_right()`** causes program execution to jump out of **`main()`** to the called function, then back to main once **`turn_right()`** is completed
- A function call therefore affects the program's flow of control
- Conditionals and loops are other mechanisms used for control flow
- Conditionals include **`if`** and **`if-else`**
- Loops include **`for`** and **`while`**
- Let's look at each of these in turn

Python Conditionals

`if` Statement

- An **`if`** statement performs the block of code indented inside it only when the associated condition is **`True`**, and only once
- An example **`if`** statement that you might see and use with Karel:

```
if front_is_clear():
    move()
```

- Note that **`move()`** is indented below the **`if`** clause. As with functions, indentation is meaningful and necessary in all Python conditionals and loops. It demarcates the **block** of commands that will be performed as part of that conditional or loop
- There can be several commands under a single **`if`**, all part of the same block

`if-else` Statement

- An **`if-else`** statement performs a block of code when the associated condition is **`True`**, or a different block of code when the condition is **`False`**
- The appropriate indented block is performed only once
- An example **`if-else`** statement that you might see and use with Karel:

```
if no_beepers_present():
    move()
else:
    pick_beeper()
```

- There can be several commands within each block

Python Loops

`while` Loop

- A **`while`** loop repeatedly performs a block of code until its associated condition evaluates to **`False`**
- The condition is evaluated before each pass through the loop
- If the condition is **`True`**, the indented block is executed
- This process repeats until the condition becomes **`False`**
- An example **`while`** loop that you might see and use with Karel:

```
while front_is_clear():
    move()
```

- This loop is also called an *indefinite loop* because we don't know in advance how many times it will run

`for` Loop

- A **`for`** loop performs its block of code a specified number of times
- An example for loop that you might see and use with Karel:

```
for i in range(3):
    turn_left()
```

- **`i`** is a conventional name for the counter, from integer. The underscore **`_`** is also a very common counter. But you can call the counter anything, even **`jane`** or **`bob`**
- The counter is incremented after each pass through the loop
- This loop is also called a *definite loop*, because we know when it ends: when the counter reaches the specified number

Functions

Functions

- The process of breaking down a problem into smaller, self-contained building blocks is **decomposition**
- These smaller building blocks are **functions**
- A function is a sequence of steps that achieves a specific outcome
- Any set of steps that needs to be repeated could be made a function
- So could any logically self-contained portion of the program
- A sample function you might see and use with Karel:

```
def turn_right():
    for _ in range(3):
        turn_left()
```

Advantages of using functions

- **Readability** : a single statement **`turn_right()`** is easier to understand than three consecutive **`turn_left()`** statements
- **Repeatability** : If Karel needs to turn right several times in a program (e.g., as in Archway), using this function can help us avoid writing the same code over and over again
- **Reliability** : Using functions makes the code modular and easier to debug, as we can test each function out after writing it to make sure it works rather than having to test the whole program at once

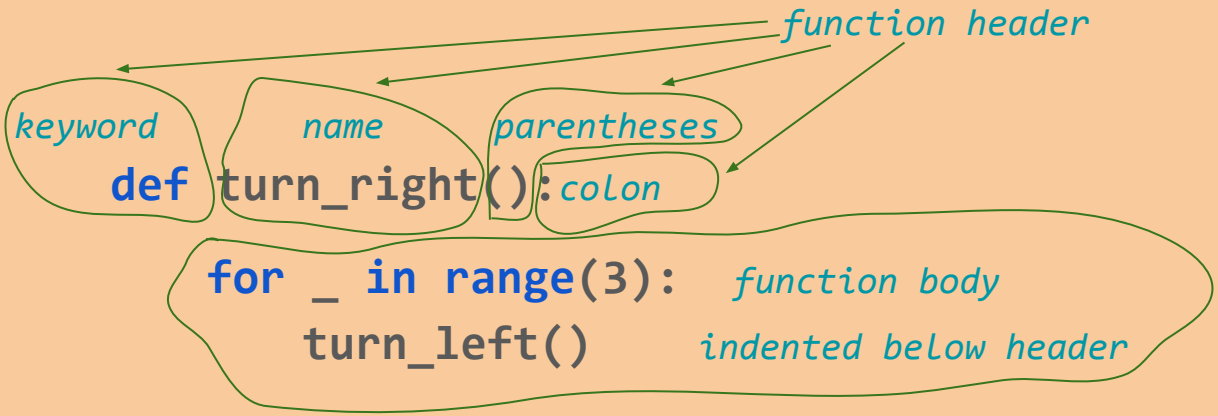
Function Structure (Slide 1 of 2)

- The function header is at the top of the function definition:

```
def function_name():
```

- The header starts with the keyword **`def`** followed by the function name
- The function name should briefly but clearly state what the function does
- The function name is followed by a pair of parentheses **`()`**
- The function header ends with a colon **`:`**
- The function body is an indented block below the header. It includes all the commands necessary for the function to do its work

Function Structure (Slide 2 of 2)



Reminder: An Overview of Programming

- A program is a sequence of steps. Each step is an instruction or **command**
- The steps are intended to get from a certain condition to a desired result
  - The starting condition is the **precondition**
  - The desired result is the **postcondition**
- Solving a programming problem involves
  - Identifying the precondition and postcondition. This is **understanding the problem**
  - Figuring out what steps are needed to get from precondition to postcondition. This is **designing the solution** . Usually, the solution is designed using ordinary language, not code
  - Coding the steps. This is **implementing the solution** . This is very hard, almost impossible, if you have not designed the solution first; it is very easy if you have designed the solution well
  - Finally, making the solution better: going over the program to fix errors, deal with special cases, or identifying ways to make the steps more efficient. This is an **iterative process of refinement**

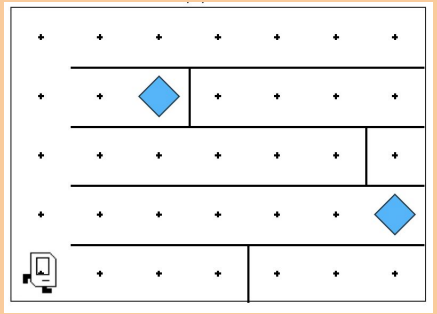
Decomposition

- First, understand the pre- and postconditions
- While designing the solution, identify the repeatable, self-contained building blocks that will be the functions
- When coding, assume the functions are done
  - Write out the function headers
  - Use the `pass` keyword for the bodies
- Assemble the functions in `main()` to solve the overall problem
- Implement each building block by writing out its function body
- Test iteratively:
  - Test each function after it is written and fix any problems
  - Test the whole program to make sure it works as intended, and fix any problems

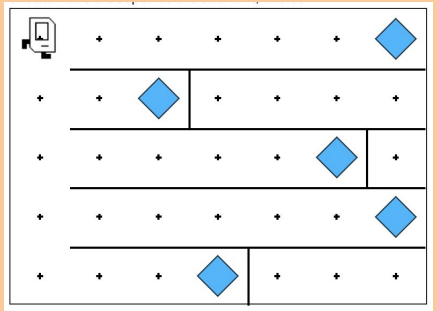
Worked Example: Five Corridors

Understanding Five Corridors

- Preconditions:
  - Karel is facing east at the bottom left corner of a world with five rows
  - Each row is a corridor ending at a wall
  - Some rows may have a beeper directly before the wall



- Postconditions:
  - Karel is facing east at the top left corner of the world
  - All rows have a beeper before the wall



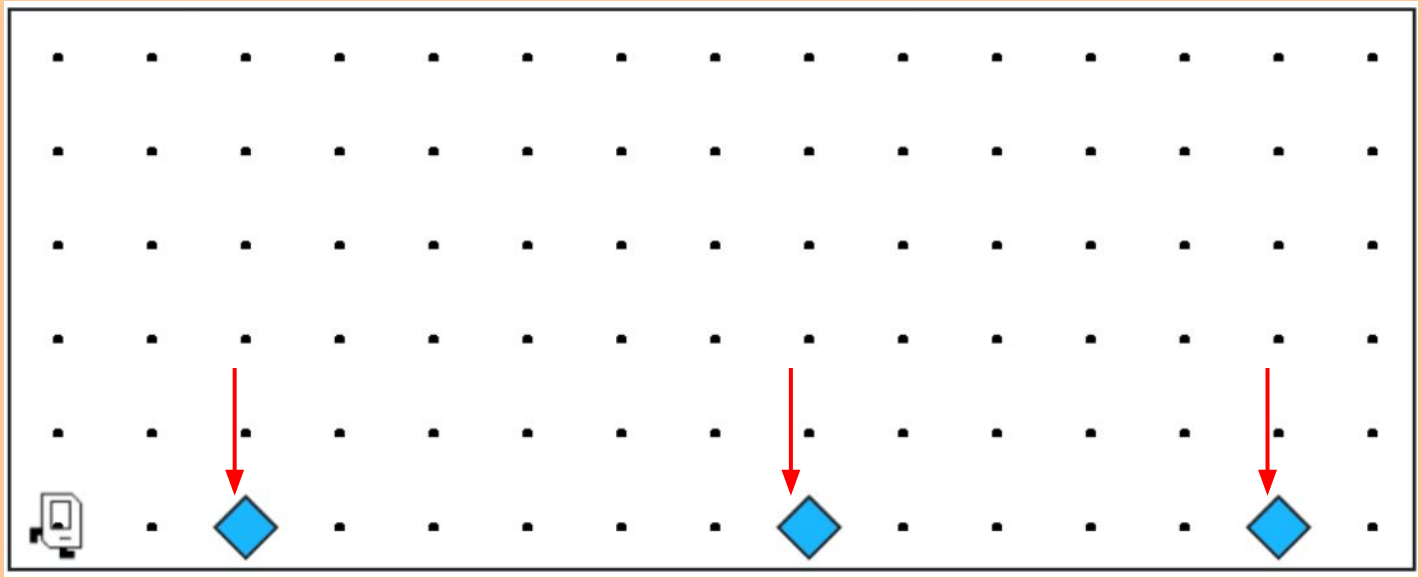
Designing, Implementing, and Testing the Solution

- Design:
  - What does Karel need to do for **one** row?
  - How many times does Karel need to do this?
  - What would be a good control flow mechanism to use?
  - What are the steps involved in the overall solution?
  - What are likely candidates for functions? I.e., what repeatable, modular building blocks can we use in the steps?
- Implement and test:
  - Write out all function headers and use `pass` for the bodies
  - Write out `main()` assuming all the functions have been implemented
  - Implement and test each function iteratively
  - Test `main()` and refine the overall solution

Section Problem: Hospital Karel

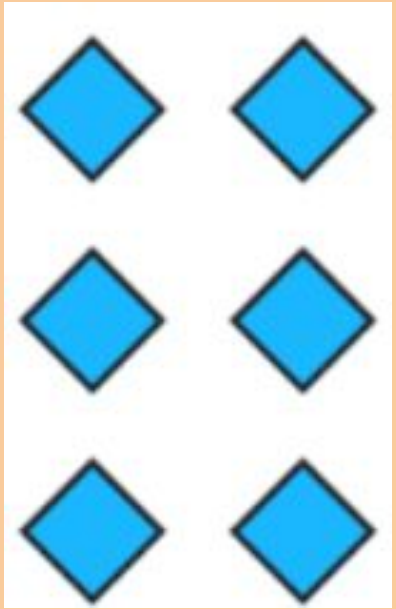
Hospital Karel Preconditions (Slide 1 of 3)

Karel starts facing east at [1, 1] with an infinite supply of beepers in its bag. Each beeper in the bottom row represents a location where Karel should build a hospital:



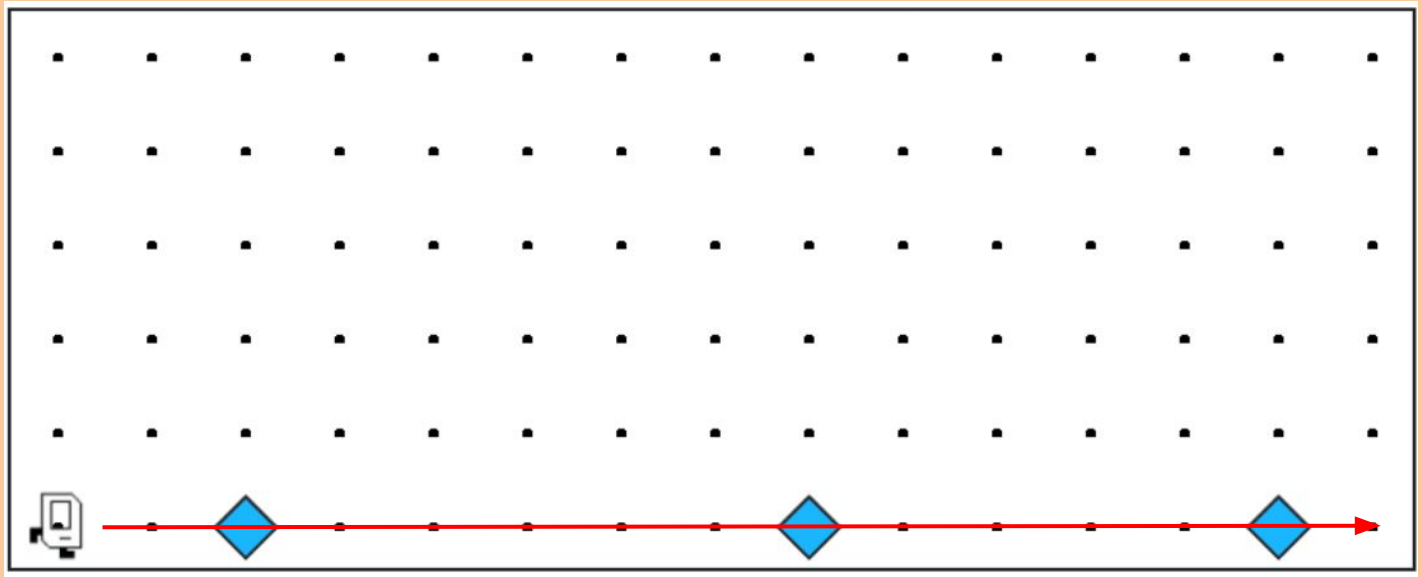
Hospital Karel Preconditions (Slide 2 of 3)

The hospitals Karel should build are a 3 x 2 rectangle of beepers:



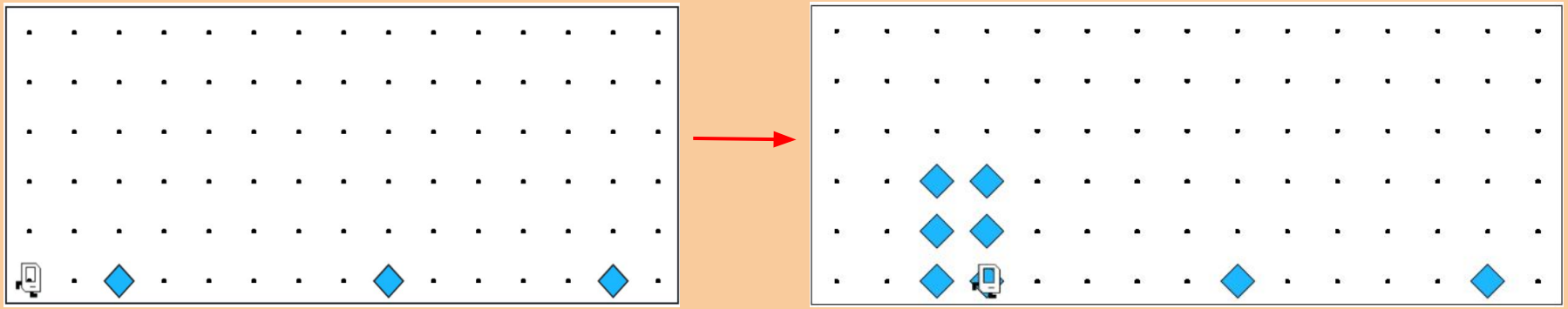
Hospital Karel Preconditions (Slide 2 of 3)

Karel must walk the row and build a hospital at each location. The beepers indicating the locations will be spaced such that there will be no overlapping or hitting walls:



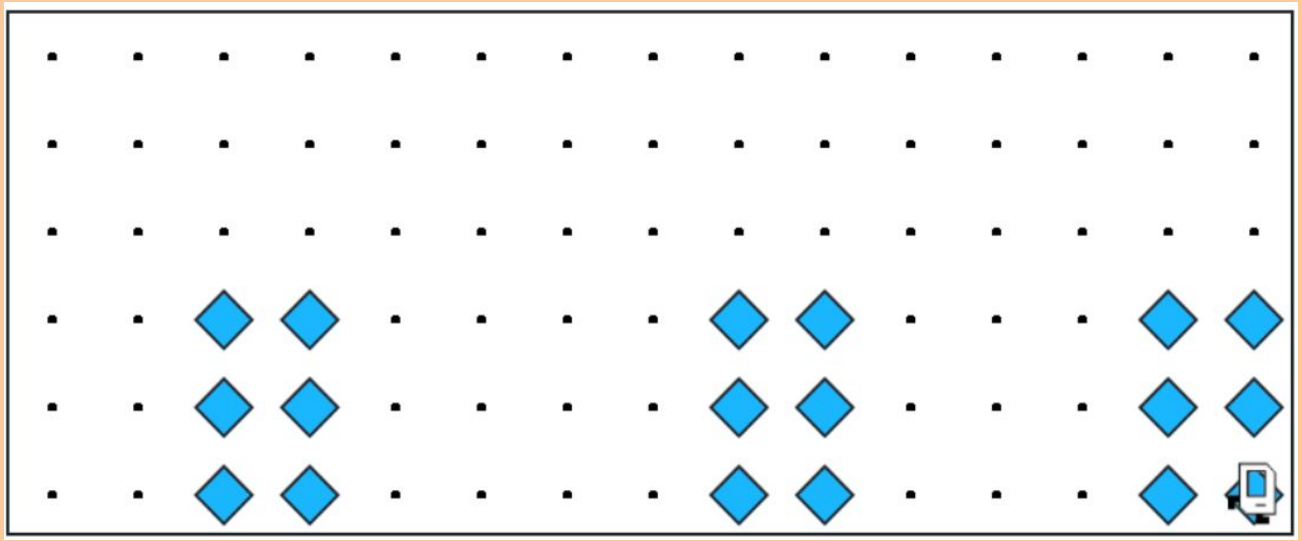
Hospital Karel Postconditions (Slide 1 of 2)

Here is the state after Karel has built the first hospital:



Hospital Karel Postconditions (Slide 2 of 2)

For the initial set of conditions shown, the result should look like this. Karel should not run into the wall after building the hospital that extends to the final corner:



Hospital Karel Hints

- Decompose the solution thoroughly.
- You might want to consider whether building a hospital can be further broken down into twice building a column of three beepers. If you do this, make sure you don't end up with two beepers at the starting point for each hospital
- Be prepared to iterate over the solution. Tackle fencepost problems (such as the possibility of a hospital's being located on the leftmost corner) *after* you have tackled the general case
- Your program should work for any world that meets the preconditions; do not engineer it specifically for one world, e.g., by counting the number of hospitals and/or corners

That's all, folks!

Next up: Problem Solving