In [ ]:
```
from cs103 import *


```

# CPSC 103 - Systematic Program Design

# Module 06 Day 1

Rik Blok, with thanks to Giulia Toti and Karina Mochetti

---

# Reminders

- **this** Wed-Fri: tutorials drop-in sessions for project help
- Wed: Module 5 (Arbitrary-Sized): Code Review
- Wed: Module 5 (Arbitrary-Sized): Tutorial Submission
- **Thu:** Open office hours for project help in lieu of lecture
- **Fri:** Project Proposal
- **next** Wed-Fri: Module 6 Tutorial Attendance

### ⚠ Project Proposal

**DUE:** Friday Nov 3

- Work with your partner if you formed a team
- You may use provided information source or propose your own
- If you are proposing your own information source:
  - Information must be in a CSV file
  - Information must be open (i.e., licensed for use in a course project)
  - Needs to be "enough" information, and it must be "complex enough" (e.g., at least three columns and at least 100 rows)
  - Upload the information with your proposal
  - Have in mind one of our provided information sources as a backup plan
- You will need to answer:
  1. What is your information source?
  2. What question or topic do you want to explore?
  3. What graph or chart do you intend to produce?
  4. What substantial computation do you plan to perform? (E.g., simply filtering the data and then plotting it is **NOT** a substantial computation.)

See your Canvas calendar (https://canvas.ubc.ca/calendar) for details.

---

# Your progress so far

### How to Design Functions

### 6 Data types and their template functions:

- Simple atomic
- Interval
- Enumeration

- Optional
- Compound
- Arbitrary-size

### The reference rule

But the reference rule is not the only case where helper functions are needed. In this module we'll explore other cases.

---

# Module learning goals

By the end of this module, you will be able to:

- Design functions that each focus on one task (i.e. that follow the "one task per function" rule).
- Understand the helper rules.
- Review the reference rule and practice composition.

---

# Example: One task per function

**Problem 1:** Write a program that turns on the heat in a room if it goes below 20 Celsius, where you have a thermometer that reads Fahrenheit.

**Solution (with multiple tasks per function):**

```
def turn_on_heat(f: Fahrenheit) -> bool:
    """
    Returns True if the temperature f (given in Fahrenheit)
    is below 20 Celsius.
    """
    c = (5/9) * (f - 32)  # Task 1: Fahrenheit to Celsius
    return c < 20         # Task 2: Turn on heat?
```

**Problem 2:** Write a program that sounds an alarm if a fridge temperature rises above 7 Celsius, where you have a thermometer that reads Fahrenheit.

**Solution (with multiple tasks per function):**

```
def sound_fridge_alarm(f: Fahrenheit) -> bool:
    """
    Returns True if the temperature f (given in Fahrenheit)
    is above 7 Celsius.
    """
    c = (5/9) * (f - 32)  # Task 1: Fahrenheit to Celsius
    return c > 7          # Task 2: Sound alarm?
```

### Benefits of "one task per function"

Why would it not be a good idea to design a program containing both these functions this way. How could we improve the design?

▸ ℹ️ Hints (for your review after class)

---

# iClicker question: One task per function

Which of the following are reasons for doing one task per function in programming? Select ALL that apply. [Set question type to "Multiple Answer".]

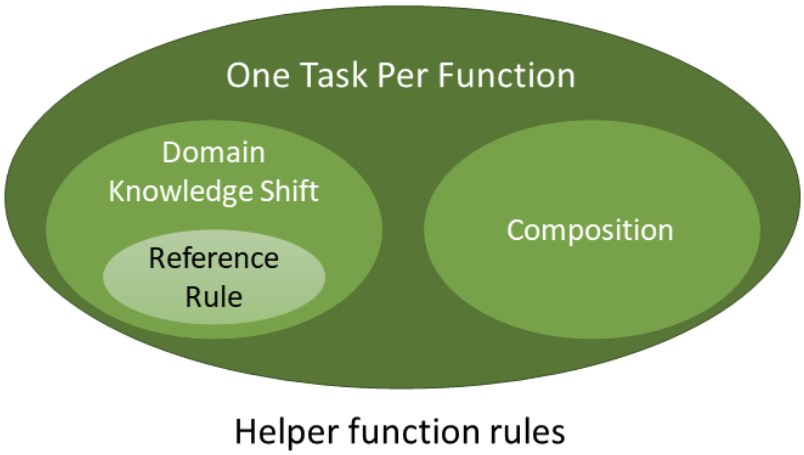
A. Separation: Each function is responsible for one specific thing and doesn't need to worry about other unrelated tasks.
B. Reusability: Each function can be easily reused in different parts of the code, making it more modular and easier to maintain.
C. Fewer functions: Each function does less, so there are fewer functions in the program.
D. Performance: Smaller, more focused functions always leads to better performance, as it can avoid the overhead of calling multiple functions.
E. Readability: The code becomes more readable and easier to understand. It can also make it easier to debug and test.

► ℹ️ Hint (for your review after class)

---

# Helper rules

Each function should have one simple task that it does and it should hand off to other functions any additional tasks.




Helper function rules

---

# When is a helper needed?

**Reference:** Use a helper function when making *references* to other non-primitive data definitions (this will be in the template).

**Knowledge Domain Shift:** Use a helper function if a subtask involves *knowledge* about a type that is not taken as input by this function.

**Composition:** When your solution is *composed* of multiple, separate operations, use a helper function for each distinct and complete operation that must be performed on the input data.

---

# Reference

- When we are solving a problem using a non-primitive data `A` and this data contains another non-primitive data `B`.
- We usually put this in the template.
- Examples:
  - When processing a `List` (non-primitive data) of `Velocity` (non-primitive data).
  - When designing a function for `CD`, a compound data which includes a release `Date` (non-primitive type).

---

# Knowledge domain shift

- The reference rule is a special case of *knowledge domain shift*.
- Other than that, it usually happens when we have a primitive data type representing a more complex data.
- Usually, when we apply *knowledge domain shift* in this course, it will be through the reference rule.

Let's look at an example...

# iClicker question: Knowledge domain shift

Consider the two alternative functions (below) to construct an annual agenda. Both represent a month as an integer. Which of the following handles a knowledge domain shift better?

**(A)**

```
def fill_agenda(a: Agenda,
                month: int) -> ...:
    for ...:
        month = month + 1
        if month == 13:
            month = 1
        add_to_agenda(a, month)
```

**(B)**

```
def fill_agenda(a: Agenda,
                month: int) -> ...:
    for ...:
        month = inc_month(month)


        add_to_agenda(a, month)
```

▶ ℹ Hint (for your review after class)

---

# Composition

- When we are solving a problem that requires several steps in sequence.
- We usually want our functions to be small and have a clear purpose.
- When you see an opportunity to break down a task and delegate a step to a new helper, do it!

---

# iClicker question: Top-down approach to helper functions

Last class we designed multiple functions using a *top-down* approach. Below are the steps to take to design a main and helper function with a top-down approach... but the list is scrambled!

1. Complete the implementation of your main function
2. Test your main function
3. Call the helper function in your main function
4. Design the helper function, including testing

5. Write the helper function stub

You are implementing your main function and realize you need a helper function. With a top-down approach, in what order should you take the above steps? Select ALL that apply. [Set question type to "Multiple Answer".]

A. First step 4, then 1, 3, 5, and finally 2.
B. First step 5, then 2, 4, 1, and finally 3.
C. First step 3, then 5, 1, 4, and finally 2.
D. First step 3, then 1, 5, 4, and finally 2.
E. First step 2, then 5, 4, 1, and finally 3.

► ℹ️ Hint (for your review after class)

---

# Exercise: `EpisodeDuration` with composition

The data below represents the length of episodes from a TV show, in minutes. We have examples for only one episode of a show (Friends), a full season of a show (Game of Thrones), and a whole show (The Good Place).

In [ ]:
```
from typing import List

EpisodeDurations = List[float] # in range [0, ...]
# interp. the duration of episodes in minutes for some number of
# episodes of a TV Show

ED0 = []
ED_FRIENDS_S01E01 = [22.8]
ED_GAME_OF_THRONES_S01 = [61.62, 55.28, 57.23, 55.62, 54.27, 52.6,
                          57.79, 58.13, 56.27, 52.62]
ED_GOOD_PLACE = [
    26.27, 21.50, 24.90, 22.55, 26.30, 26.35, 24.23, 25.23, 24.88,
    23.78, 26.62, 21.53, 26.88, 42.68, 21.60, 23.92, 25.37, 24.65,
    23.28, 23.72, 21.60, 24.78, 22.77, 23.47, 24.33, 21.60, 21.55,
    21.60, 21.60, 21.60, 21.53, 21.55, 21.53, 21.53, 22.53, 21.53,
    21.53, 21.53, 22.42, 21.40, 21.42, 21.43, 21.43, 21.42, 21.42,
    21.40, 21.42, 21.42, 21.45, 21.43, 52.48
]

# template based on arbitrary-sized
@typecheck
def fn_for_ed(ed: EpisodeDurations) -> ...:
    # description of the accumulator
    acc = ...   # type: ...

    for duration in ed:
        acc = ...(duration, acc)

    return ...(acc)


```

## Original problem and solution from Module 05b Day 2

**Problem:** Design a function that finds the average duration (in minutes) of all episodes in an `EpisodeDurations` list.

Recall, we already solved this problem in **Module05b-day2** (see cell below). But our solution implemented two tasks in one function, making it a bit hard to read and maintain.

---

## Solution from Module 05b Day 2

In [ ]:

```python
# Solution from Module 05b Day 2

@typecheck
def avg_episode_duration(ed: EpisodeDurations) -> float:
    """
    Return the average duration (in minutes) of the episodes in ed.

    (The average duration of zero episodes is returned as 0.)
    """
    # return 0.0  #stub
    # Template from EpisodeDurations

    # sum of episode durations so far
    total = 0.0   # type: float

    # count of episodes so far
    count = 0   # type: int

    for duration in ed:
        # acc = ...(duration, total, count)
        total = total + duration
        count = count + 1

    if count == 0:
        return 0

    return total / count


start_testing()

expect(avg_episode_duration([]), 0.0)
expect(avg_episode_duration([1, 1, 1, 1, 1]), 1)
expect(avg_episode_duration([100.12, 12.1]), (100.12+12.1)/2)
expect(avg_episode_duration(ED_GAME_OF_THRONES_S01),
       (61.62+55.28+57.23+55.62+54.27+52.6+57.79+58.13+56.27+52.62)/10
      )
expect(avg_episode_duration(ED_FRIENDS_S01E01), 22.8)

summary()

```

## One task per function solution via composition

Let's tackle the problem again but with the "one task per function" principle, using our newly-learned *composition* rule.

We'll see how we split the steps in the task into separate helper functions.

## Composition steps?

Let's work out what steps we'll need to take to compose our solution:

In [ ]:

```python
# Steps:
# 1.
# 2.
# 3.
# 4.
```

▶ ℹ Solution (for your review after class)

## Space reserved for helper functions

In [ ]:
```
# TODO: Add any added/changed helper functions here after designing the main function be
```

In [ ]:
```
# TODO: Add any added/changed helper functions here after designing the main function be
```

▶ ℹ Helper functions solution (for your review after class)

---

## Main function

Let's use a top-down approach to design our function. We begin with the main function.

In [ ]:
```
# begin by copy/pasting solution from Module05b-day2
```

▶ ℹ Main function solution (for your review after class)

---