CSc 110, Spring 2018

Lecture 3: Functions

"In return for an increase in my allowance, I can offer you free unlimited in-home computer tech support."

Algorithms

- **algorithm**: A list of steps for solving a problem.
- Example algorithm: "Bake sugar cookies"
  - Mix the dry ingredients.
  - Cream the butter and sugar.
  - Beat in the eggs.
  - Stir in the dry ingredients.
  - Set the oven temperature.
  - Set the timer for 10 minutes.
  - Place the cookies into the oven.
  - Allow the cookies to bake.
  - Spread frosting and sprinkles onto the cookies.
  - ...

Problems with algorithms

- *lack of structure*: Many steps; tough to follow.
- *redundancy*: Consider making a double batch...
  - Mix the dry ingredients.
  - Cream the butter and sugar.
  - Beat in the eggs.
  - Stir in the dry ingredients.
  - Set the oven temperature.
  - Set the timer for 10 minutes.
  - Place the first batch of cookies into the oven.
  - Allow the cookies to bake.
  - Set the timer for 10 minutes.
  - Place the second batch of cookies into the oven.
  - Allow the cookies to bake.
  - Mix ingredients for frosting.
  - ...

Structured algorithms

- **structured algorithm**: Split into coherent tasks.

1 Make the batter.

- Mix the dry ingredients.
- Cream the butter and sugar.
- Beat in the eggs.
- Stir in the dry ingredients.

2 Bake the cookies.

- Set the oven temperature.
- Set the timer for 10 minutes.
- Place the cookies into the oven.
- Allow the cookies to bake.

3 Decorate the cookies.

- Mix the ingredients for the frosting.
- Spread frosting and sprinkles onto the cookies.

...

Removing redundancy

- A well-structured algorithm can describe repeated tasks with less redundancy.

1 Make the cookie batter.
- Mix the dry ingredients.
- ...

2a Bake the cookies (first batch).
- Set the oven temperature.
- Set the timer for 10 minutes.
- ...

2b Bake the cookies (second batch).
- Repeat Step 2a

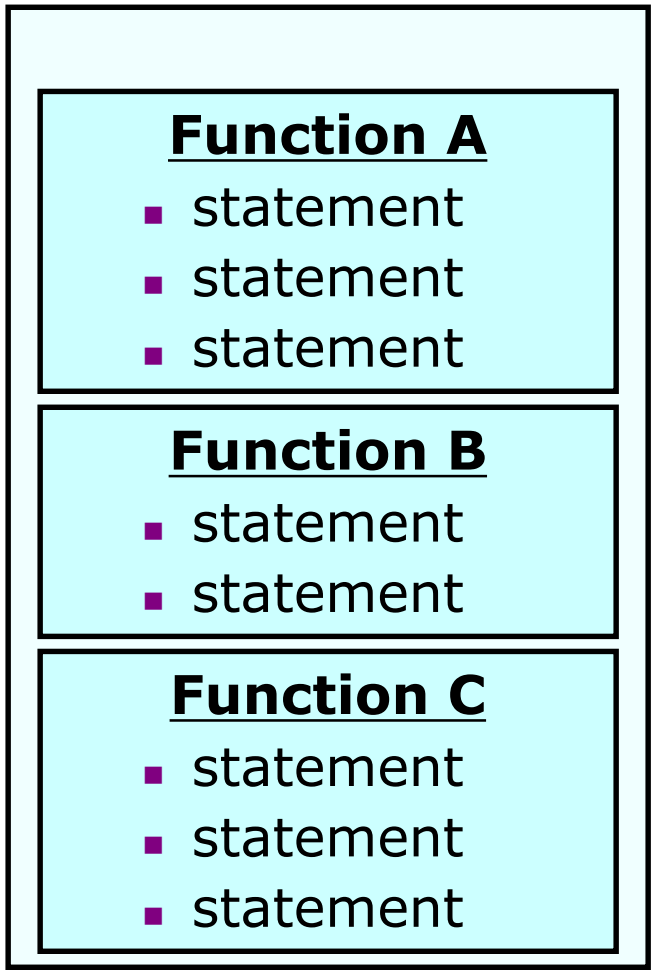
3 Decorate the cookies.
- ...

functions

- **function**: A named group of statements.
  - denotes the *structure* of a program
  - eliminates *redundancy* by code reuse

  - **procedural decomposition**: dividing a problem into functions

- Writing a function is like adding a new command to Python.



Declaring a function

Gives your function a name so it can be executed

- Syntax:

```
def name():
    statement
    statement
    …
    statement
```

- Example:

```
def print_warning():
    print("This product causes cancer")
    print("in lab rats and humans.")
```

Calling a function

Executes the function's code

- Syntax:

  name ()

  - You can call the same function many times if you like.

- Example:

```
print_warning()          #separate multiple words with underscores
```

  - Output:

```
This product causes cancer
in lab rats and humans.
```

Functions calling functions

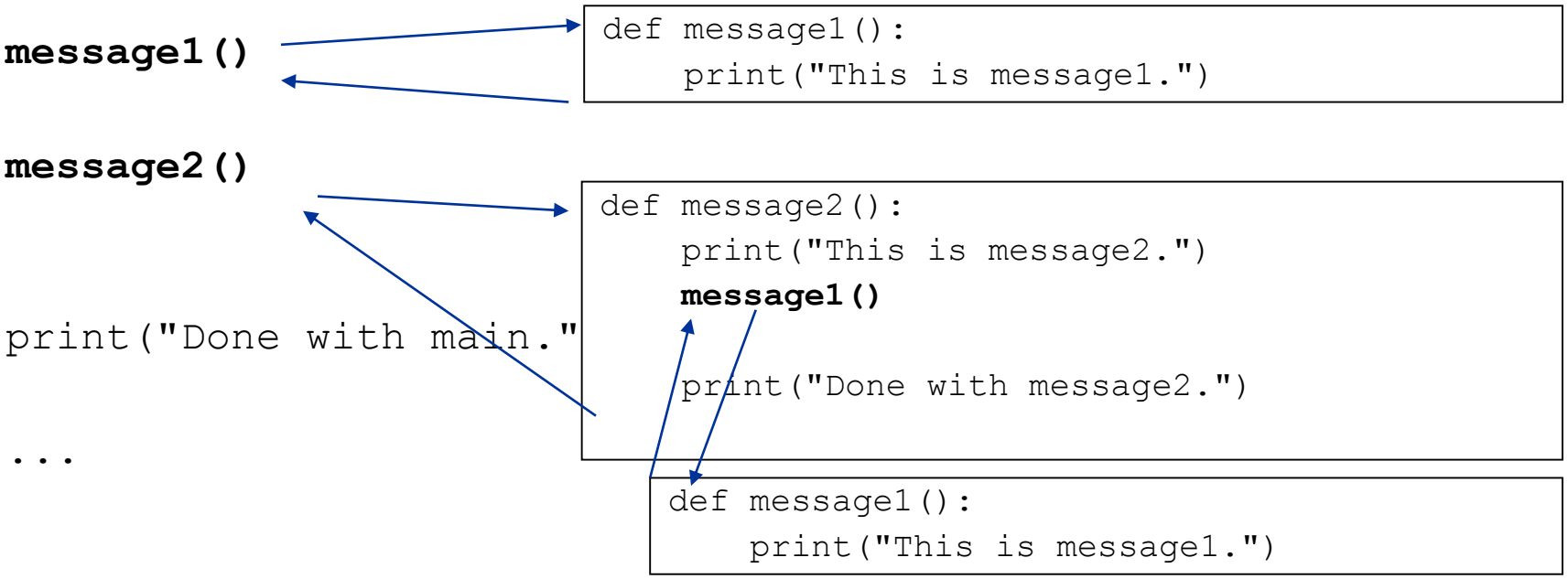
```
def message1():
    print("This is message1.")

def message2():
    print("This is message2.")
    message1()
    print("Done with message2.")

message1()
message2()
print("Done with everything.")
```

- Output:

```
This is message1.
This is message2.
This is message1.
Done with message2.
Done with main.
```

Control flow

- When a function is called, the program's execution...
  - "jumps" into that function, executing its statements, then
  - "jumps" back to the point where the function was called.



Structure of a program

- No code should be placed outside a function. Instead use a `main` function.
  - The one exception is a call to your main function

```
def main():
    message1()
    message2()
    print("Done with everything.")
def message1():
    print("This is message1.")


def message2():
    print("This is message2.")
    message1()
    print("Done with message2.")

main()
```

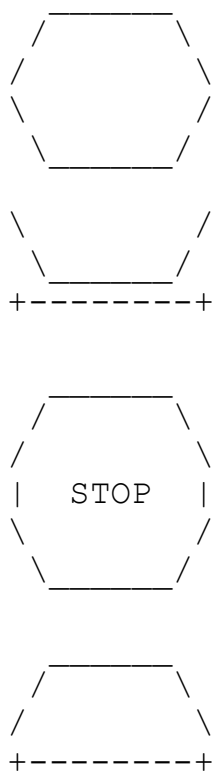
When to use functions (besides `main`)

- Place statements into a function if:
  - The statements are related structurally, and/or
  - The statements are repeated.

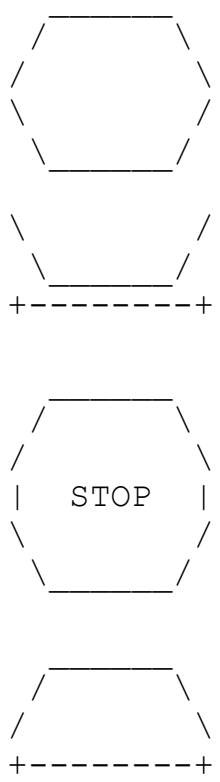
- You should not create functions for:
  - An individual `print` statement.
  - Only blank lines.
  - Unrelated or weakly related statements.
    (Consider splitting them into two smaller functions.)

Functions question

- Write a program to print these figures using functions.



Development strategy



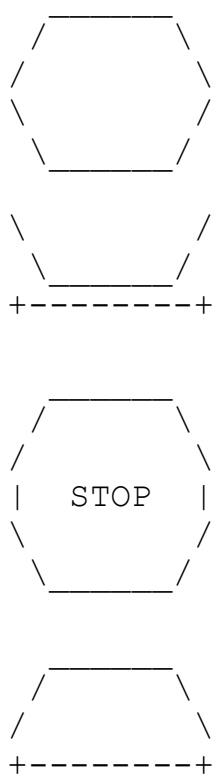
First version (unstructured):

- Create an empty program.
- Copy the expected output into it, surrounding each line with `print` syntax.
- Run it to verify the output.

Program version 1

```
def main():
    print("  ______")
    print(" /      \\")
    print("/        \\")
    print("\\        /")
    print(" \\______/")
    print()
    print("\\        /")
    print(" \\______/")
    print("+--------+")
    print()
    print("  ______")
    print(" /      \\")
    print("/        \\")
    print("|  STOP  |")
    print("\\        /")
    print(" \\______/")
    print()
    print("  ______")
    print(" /      \\")
    print("/        \\")
    print("+--------+")

main()
```

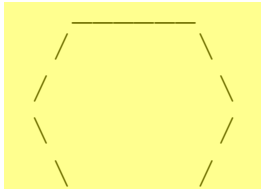
Development strategy 2

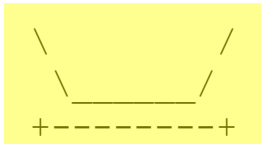


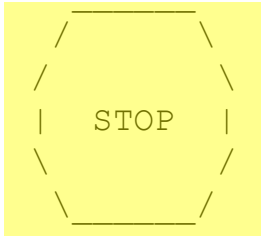
Second version (structured, with redundancy):

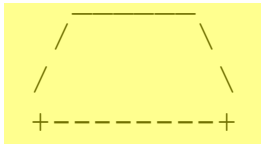
- Identify the structure of the output.
- Divide the code into functions based on this structure.

Output structure









The structure of the output:

- initial "egg" figure
- second "teacup" figure
- third "stop sign" figure
- fourth "hat" figure

This structure can be represented by functions:

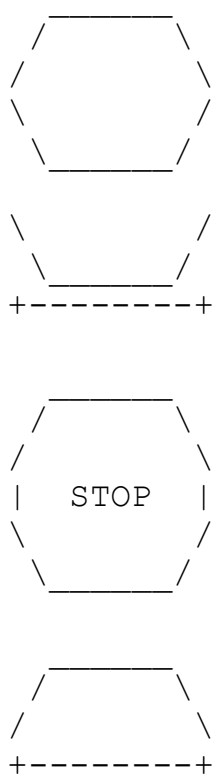
- `egg`
- `tea_cup`
- `stop_sign`
- `hat`

Program version 2

```
def main():
    egg()
    tea_cup()
    stop_sign()
    hat()

def egg():
    print("   ______")
    print(" /       \\")
    print("/         \\")
    print("\\         /")
    print(" \\______/")
    print()

def tea_cup():
    print("\\         /")
    print(" \\______/")
    print("+--------+")
    print()
```

```
def stop_sign():
    print("   ______")
    print(" /       \\")
    print("/         \\")
    print("|  STOP   |")
    print("\\         /")
    print(" \\______/")
    print()

def hat():
    print("   ______")
    print(" /       \\")
    print("/         \\")
    print("+--------+")
```

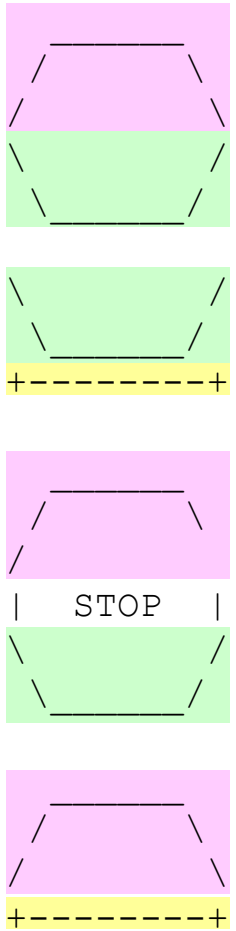
Development strategy 3



Third version (structured, without redundancy):

- Identify redundancy in the output, and create functions to eliminate as much as possible.
- Add comments to the program.

Output redundancy



The redundancy in the output:

- egg top: reused on stop sign, hat
- egg bottom: reused on teacup, stop sign
- divider line: used on teacup, hat

This redundancy can be fixed by functions:

- `egg_top`
- `egg_bottom`
- `line`

Program version 3

```
# Suzy Student, CSc 110, Spring 2094
# Prints several figures, with methods for structure and redundancy.
def main():
    egg()
    tea_cup()
    stop_sign()
    hat()

# Draws the top half of an an egg figure.
def egg_top():
    print("  ______")
    print(" /      \\")
    print("/        \\")

# Draws the bottom half of an egg figure.
def egg_bottom():
    print("\\        /")
    print(" \\______/")

# Draws a complete egg figure.
def egg():
    egg_top()
    egg_bottom()
    print()
```

```
# Draws a teacup figure.
def tea_cup():
    egg_bottom()
    line()
    print()

# Draws a stop sign figure.
def stop_sign():
    eggTop()
    print("|  STOP  |")
    egg_bottom()
    print()

# Draws a figure that looks sort of like a hat.
def hat():
    egg_top()
    line()

# Draws a line of dashes.
def line():
    print("+--------+")
```