CMPT 120

Topic: Functions – Part 4

Developing Software that incorporates Functions

Learning outcomes

At the end of this course, a student is expected to:

- Create (design) small to medium size programs using Python:
  - Decompose a Python program into **functions**
- Use the core features of Python to design programs to solve problems: variables, expressions, terminal input and output, type conversion, conditionals, iteration, **functions**, standard library modules
- Design programs requiring approximately 100 lines and 6 **functions** (of well-designed code)
- Describe the benefits of using **functions**
- Construct **functions** such that:
  - Functions have a single purpose (decomposition)
  - Functions are reusable (generalisation)
  - Functions include parameters and local variables
  - Functions return values
- etc…

Case Study

- Case study: developing software that incorporates functions
- In the process, we shall point out a few guidelines:
  - Decomposition
  - Incremental Development
  - Function Interface Design
  - Generalization
  - Composition
  - Encapsulation

Creating functions in our software

Two ways of going about this!

Way 1

- If the software does not already exist, we can design and implement our solution incorporating functions

Way 2

- If the software already exist, we can encapsulate some of its code fragments (the ones with one specific purpose/repeated code fragments) into functions

Way 1 : Developing software incorporating functions

- Incorporating functions into our software as we are developing it!

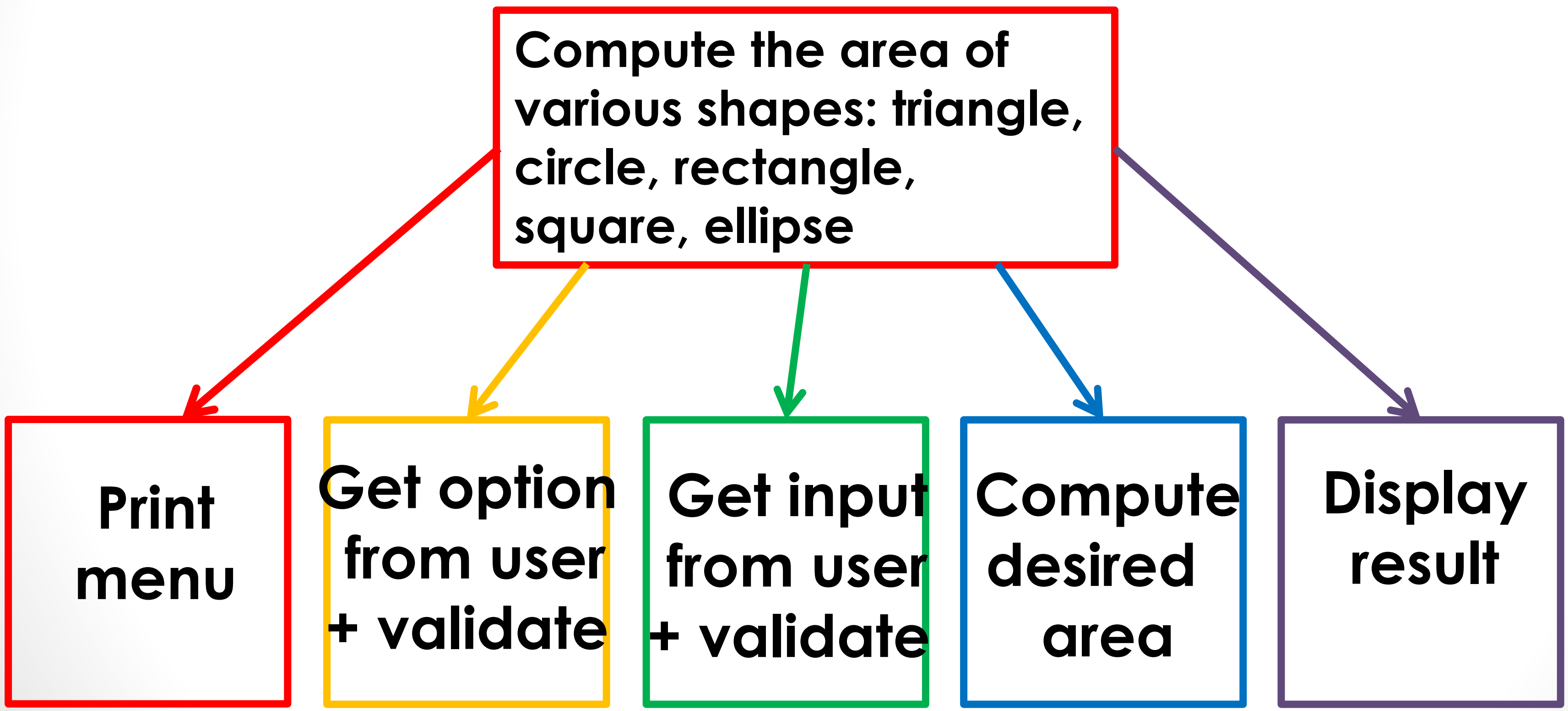
Let's illustrate the development of software (a Python program) incorporating functions with a case study called **Area Calculator**

Step 1 – Problem Statement

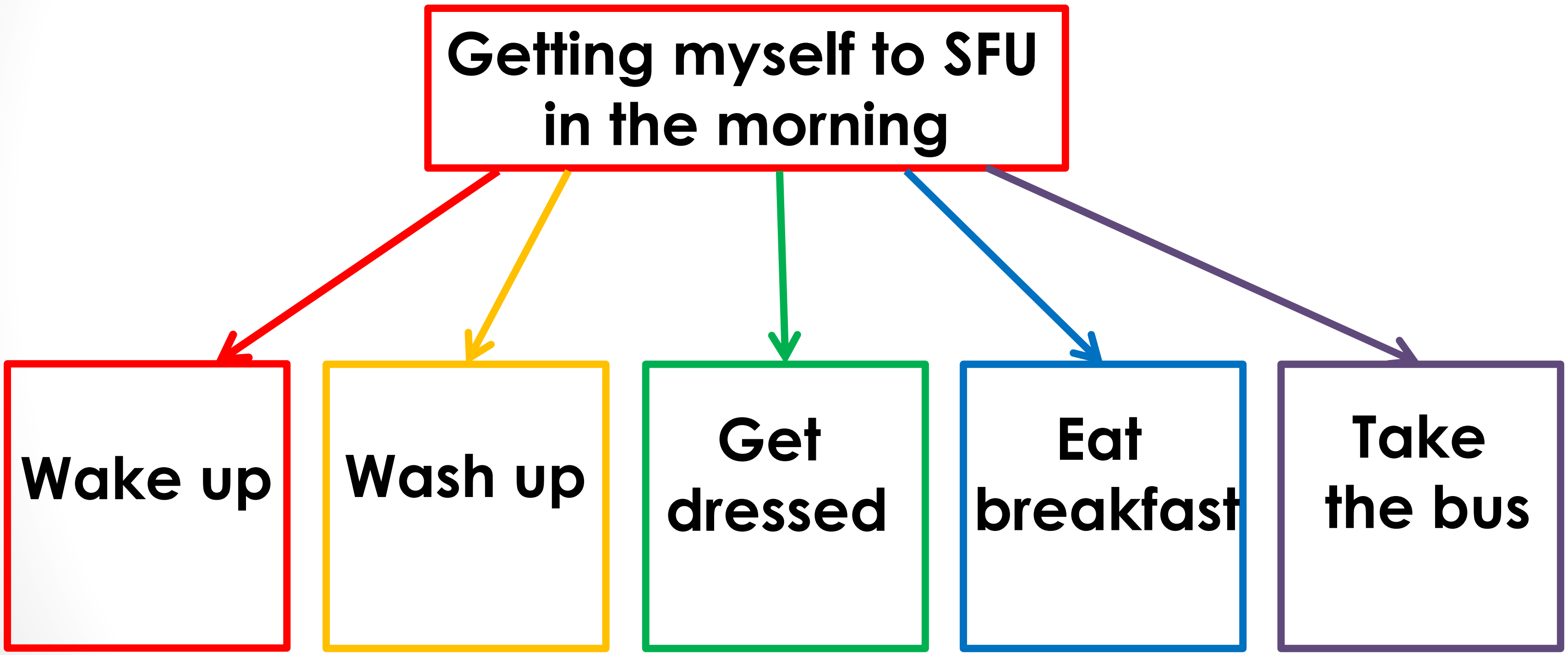
- <u>Problem statement:</u> Develop a Python program to compute the area of various shapes: triangle, circle, rectangle, square, ellipse

Step 2 – Applying Decomposition

- As we design a solution, we decompose it into actions --> functions



Decomposition in the real world



Step 2 – Algorithm

- Each action -> a step of the algorithm
- So, each of these steps has a purpose

- Note that this algorithm is not very detailed
  -> **High-level algorithm**

```
# Print menu
# Get option from user (+ validate input)
# Based on option selected by user,
#    get appropriate input from user
#    ( + validate input)
# Compute desired area
# Display result
```

So, each step **could potentially** be implemented as a **function**

For example …

Print menu

-> became the function `printMenu()`

#Get option from user (+ validate input)

-> became the function `getSelection()`

Step 2 – Low-level Algorithm

Print menu
  # Print description of program
  # Print menu displaying selection of shapes

Get options from user (+ validate input)
  # Print input instruction to user and read user input
  # Validate input

Based on option selected by user, get appropriate input from user (+ validate input)
  # If "triangle" is selected, then ask for the base and height
  # If "circle" is selected, then ask for the radius
  # if "rectangle" is selected, then ask for the width and height
  # if "square" is selected, then ask for one side
  # if "ellipse" is selected, then ask for both radii
  # Validate input

Compute desired area
  # If "triangle" is selected, then compute area = 0.5 (base * height)
  # If "circle" is selected, then compute area = pi * radius squared
  # if "rectangle" is selected, then compute area = width * height
  # if "square" is selected, then compute area = side squared
  # if "ellipse" is selected, then compute area = pi * radius1 * radius2

Display result
  # Print the shape, the input data and the area

Step 4 - Implementation

- See Area Calculator program posted on our course web site

Versions to our Case Study - 1

- AreaCalculator - version 1 : Demonstrating **incremental development** guideline by implementing and testing the first two steps of our algorithm
- AreaCalculator - version 2 : Demonstrating **incremental development** guideline by implementing the sections of our algorithm dealing with the rectangle
- AreaCalculator - version 3 : Demonstrating **incremental development** guideline by implementing the sections of our algorithm dealing with the square

Versions to our Case Study - 2

- AreaCalculator - version 4 : Demonstrating refactoring repeated code from the functions square( ) and rectangle( ) and encapsulating this repeated code into their own function:
  - **getUserInput(whichData, shape)** -> called from square( ) and rectangle( ) to get and validate side, width or height from user
  - **areaOfParallelogram(base, height)** -> called from square( ) and rectangle( ) to compute their area since square and rectangle are both parallelograms and therefore use the same area equation
  - **displayResult(theShape, area)** -> called from the main part of the program to display the result since all shapes will have a resulting area to display

Versions to our Case Study - 3

- Note: Throughout the 4 versions of our AreaCalculator, we demonstrate how to design the interface of a function
  - Function's purpose and name
  - Function's parameter(s)
  - Function's returned value

AreaCalculator – Main Loop

```
exitProgram  = 'X'
...
# Main part of the program - top level (of execution)
...
# As long as the user enters a valid selection ...
while selectedShape != exitProgram :
    area = 0
    # If "triangle" is selected?
    if selectedShape == "T":
        # deal with triangle
    # If "circle" is selected?
    elif selectedShape == "C":
        # deal with circle
    # If "rectangle" is selected?
    elif selectedShape == "R":
        theShape = "rectangle"
        area = rectangle()
    # If "square" is selected?
    elif selectedShape == "S":
        theShape = "square"
        area = square()
    # If "ellipse" is selected?
    elif selectedShape == "E" :
        # deal with ellipse
    ...
print("---")
```

printMenu() called

getSelection(…) called

displayResult(…) called

Event loop

Way 2 : Enhancing software by incorporating functions

- If the software already exist, we can encapsulate (i.e., refactor) some of its code fragments into functions using the following guidelines:
  - If a code fragment is made of logically related statements, i.e., the code fragment has **one well defined purpose**, put the code into a function and replace the code fragment in the main part of the program by a call to this function
  - If a code fragment is **repeated** in several places in the program, put the repeated code into a function and replace each instance of the repeated code in the main part of the program by a call to this function

Summary

- Developing Software that incorporates Functions
  - Way 1 – the program does not exist yet
  - Way 2 – the program has already been written

Next Lecture

- Recursion