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CP1401 Module 6
Functions 1

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Learning outcomes - you will be able to:

- Implement Python programs using functions
- Understand input parameters and returning data
- Understand and use the Single Responsibility Principle (SRP)
- Name functions well using meaningful verb phrases

(Later, in Functions 2)

- Test functions with meaningful test values
- Design larger programs using smaller functions (decomposition)

Do this now

- Write a program to ask the user for their age, making sure it's valid (0-150); then print whether they are:
  - child (0-17)
  - adult (18-64)
  - geriatric (65+)

- What data should you use to test this program?

Pseudocode

```
get age
while age < 0 or age > 150
    print error message
    get age
if age < 18
    print child
else if age < 65
    print adult
else
    print geriatric
```

Standard while loop pattern

if-elif-else pattern

Python

```
age = int(input("Age: "))
while age < 0 or age > 150:
    print("Invalid age")
    age = int(input("Age: "))
if age < 18:
    print(f"At {age} years old, you are: child")
elif age < 65:
    print(f"At {age} years old, you are: adult")
else:
    print(f"At {age} years old, you are: geriatric")
```

This next bit is so random

- Remember our guessing game:

```
SECRET = 6
guess = int(input("? "))
while guess != SECRET:
    print("Guess again!")
    guess = int(input("? "))
print("You got it!")
```

- How can we make this more interesting by making the secret **random**?
  - By using the random module

Use the random module to do random things

```
import random

secret = random.randint(1, 10)
print(secret)
```

- First, we need to **import** the random **module**.
- Then we have access to many new functions, including `randint`.
- randint takes 2 parameters, the low and high bounds for generating a random number (1-10 inclusive in this example).

random.randint can use any meaningful **arguments**

```
import random

low = int(input("Low: "))
high = int(input("High: "))
secret = random.randint(low, high)
guess = int(input("? "))
while guess != secret:
    print("Incorrect")
    guess = int(input("? "))
print("Got it!")
```

Notice that this is now **secret** instead of **SECRET**.
Never name variables like CONSTANTS

So, what have we got here? Let's break it down.

```
secret = random.randint(low, high)
```

- random is a **module** - a file that contains other code we can use
- randint is a **function** - a reusable piece of code that we can **call**
- low and high are **arguments** - the parameters that change how the randint function works when we call it
- secret is a variable that stores the what the randint function **returns**

The random module contains many more functions,but that will do us for now.

Do this now

Write a complete program (including import at the top) that asks the user for their age, then tells them how old they will be in a random number of years (where that random number is between 1 and their age)

Example:

```
Age: 42
In 40 years, you will be 82
```

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Functions

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As programs get larger, we need constructs to manage them

- Larger programs can sometimes be written all in one section, but:
  - Large programs can be hard to read –
    Programmers sort of have to hold the whole thing in their mind at once instead of thinking of just one piece at a time
  - We may have **code that performs the same task in multiple places**
    - Repetition structures can help with reducing duplicated code, but not always
    - Often, our repeated tasks are really like a sub-program, or… **function!**

Functions allow us to break larger programs into smaller, more manageable pieces

- A function is a named group of statements within a program that performs a specific task
  - Usually one task of a large program

- We can break off chunks and solve them as separate parts
  - This is **decomposition** - decomposing a large problem into smaller problems that are easier to solve
  - When the problems are smaller versions of the same overall problem, this is known as the *divide and conquer* approach

Here's a very simple function example

```
def print_line():
    print("-" * 20)


print_line()  # --------------------
```

Let's add a parameter to customise the function

```
def print_line(length):
    print("-" * length)


print_line(20)  # --------------------
```

Here's a complete program using that function

```
def main():
    print_line(20)
    print("Welcome!")
    print_line(8)
```

main function **definition**

print_line function **call**

```
def print_line(length):
    print("-" * length)
```

print_line function **definition**

```
main()
```

main function **call**

```
--------------------
Welcome!
--------
```

Deconstructing function **definitions** in Python

```
def function_name(parameters):
    statement
    statement
```

- First line includes the keyword `def` followed by a function name, then brackets with a list of parameters followed by a colon. This is the function **header**.
  - We can have zero, one, or more parameters
  - Indenting defines the **body** of the function

Deconstructing function **calls** in Python

```
function_name(arguments)
```

- We've done this a lot already:
  - `print, input`… what other built-in functions have we used?

- Simply use the function's name followed by round brackets that contain any arguments. `print("Hello world")`
- If a value is returned, then we probably want to use it:

```
age = int(input("Age: "))
age = get_age()
```

We can pass arguments to functions that take them

- An argument is a piece of data that is sent into a function
  - In `print("Hello")`, "Hello" is the argument.
  - Functions can use arguments in their bodies, so we use them to customise what a function does (like we did with random numbers)
  - An argument can be anything that evaluates to a value (expression), including a variable, constant, other function, a literal... Example:

```
name = input("Name: ")
print("Hello", name)
```

What are all the arguments here?

Arguments get passed to function parameters

- "Parameter" is what we call the variable inside the function that is assigned the value of an argument when the function is called
  - A parameter's **scope** is the whole function in which the parameter is used.

```
def print_line(length):
    print("-" * length)


print_line(10)
```

Parameter

length = 10

Argument

We can pass multiple arguments (if the function has multiple parameters)

- Python allows writing functions that accept multiple arguments
  - The parameters passed in are referred to as a parameter list
  - Parameter list items are separated by comma(s)
- Arguments are passed by position to corresponding parameters
  - The first parameter receives value of first argument, second parameter receives value of second argument, etc.

```
def print_grid(rows, columns):
    # do this now (print a grid of *s)

print_grid(3, 7)
```

These are called "positional arguments"

Do this now

```
def print_grid(rows, columns):
    # complete this function to print a grid of *s


print_grid(3, 7)
```

```
*******
*******
*******
```

Many functions return values

- We often write code like:

```
name = input("Name: ")
number = int('42')
value = random.randint(1, 10)
```

- So, these functions all **return** a value
  - This means these function calls **evaluate** to the value they **return**
  - `int('42')` evaluates to the integer `42`
- We can write our own functions that return values

Use the **return** statement to return a value

- Consider a function to calculate the BMI (Body Mass Index), as seen in practicals

```
def calculate_bmi(height, weight):
    return weight / (height ** 2)
```

- The function has two parameters, height and weight. These could come from user input, random numbers or whatever.
  - It does not ask the user for these inputs
- The function **returns** the result of the calculation
  - It does not print the value

Here's the complete BMI program

```
def main():
    height = float(input("Height (m) : "))
    weight = float(input("Weight (kg): "))
    bmi = calculate_bmi(height, weight)
    print(f"Your BMI is {bmi}.")


def calculate_bmi(height, weight):
    return weight / (height ** 2)


main()
```

Here's another program that uses the same function

```
def main():
    height = random.uniform(1, 2)
    weight = random.randint(44, 99)
    if calculate_bmi(height, weight) < 15:
        print("Not considered overweight")


def calculate_bmi(height, weight):
    return weight / (height ** 2)
```

See how we can use the exact same function for a different program with no user inputs and not printing the result?

```
main()
```

Functions should "do one thing"

- The **Single Responsibility Principal** (SRP) is the most important function design consideration
- **Functions should not usually print** unless that's their one thing
  - Instead, they should **return their result**
  - Then we can use the returned value to print or do other things
- Functions should not usually get user input, unless that's their job
  - Then we can get the required inputs from user or other places
- If a function does too many things, it should probably be "refactored" into multiple functions

These functions each have a single responsibility

- This function's one job is to get a valid age. We can customise it by passing in low and high parameters.
  - Notice it does not print; it returns.

```
def get_valid_age(low, high):
    age = int(input("Age: "))
    while age < low or age > high:
        print("Invalid age")
        age = int(input("Age: "))
    return age
```

- This function's one job is to print a grid of asterisks.
  We can customise it by passing in rows and columns parameters.
  - Notice it does not get user input; it takes arguments

```
def print_grid(rows, columns):
    for i in range(rows):
        for j in range(columns):
            print("*", end="")
        print()
```

Take a coffee break to learn more about functions :)

Functions should be reusable

- Making coffee involves many small steps, which are grouped into overall tasks. Our functions for making coffee are:
  - grind_beans()
  - pour_espresso()
  - steam_milk()
  - combine()
- We can reuse these functions in different ways:
  - Flat white = grind_beans() + pour_espresso() + steam_milk() + combine()
  - Espresso = grind_beans() + pour_espresso()
  - Hot chocolate = make_chocolate() + steam_milk() + combine()
  - Take-home grinds = grind_beans()

Don't limit function reusability

- What if we tried to make it simpler by making the first step automatically call the second step and so on?
  - grind_beans() calls pour_espresso() calls steam_milk() calls combine()
- Seems easier, but…
  what then if we wanted an espresso or a hot chocolate?
  - NO.
    When we try to get just an espresso, it automatically goes on to steam milk…
    When we just want steamed milk for a babycino or hot chocolate…
    Also not possible.

Functions are often used for sections of a program

- Let's look at the age program we wrote earlier and think about the **sections** in it.

Python

```
age = int(input("Age: "))
while age < 0 or age > 150:
    print("Invalid age")
    age = int(input("Age: "))
if age < 18:
    print(f"At {age} years old, you are: child")
elif age < 65:
    print(f"At {age} years old, you are: adult")
else:
    print(f"At {age} years old, you are: geriatric")
```

Input "section"

Another section

Let's break that up into 2 sections using functions:

```
def main():
    age = get_age()
    if age < 18:
        print(f"At {age} years old, you are: child")
    elif age < 65:
        print(f"At {age} years old, you are: adult")
    else:
        print(f"At {age} years old, you are: geriatric")


def get_age():
    age = int(input("Age: "))
    while age < 0 or age > 150:
        print("Invalid age")
        age = int(input("Age: "))
    return age
```

```
main()
```

Now we've got a main program in two sections

```
def main():
    age = get_age()
    if age < 18:
        print(f"At {age} years old, you are: child")
    elif age < 66:
        print(f"At {age} years old, you are: adult")
    else:
        print(f"At {age} years old, you are: geriatric")


def get_age():
    age = int(input("Age: "))
    while age < 0 or age > 150:
        print("Invalid age")
        age = int(input("Age: "))
    return age


main()
```

`main()` looks like the **whole** program - we can read it and understand it all (not all details)

Here, we **call** `get_age()`

`get_age()` is a function that represents a section of the main program

Last, we **call** `main()`

Python programs should follow this structure

```
"""module-level docstring"""
import statements
CONSTANTS

def main():
    statements

def do_step_1()
    statements


def do_step_2()
    statements



main()
```

- top docstring for documentation
- all imports next
- define any CONSTANTS next
- then main is *always* the first function
- then define any/all other functions
- lastly, *call* main to run the program

main should "look like" the whole program

- You should be able to read (only) main and understand the whole program, with the details "abstracted away" in other functions.
- Functions should *not* call other functions that come next, but functions *can* call functions that are sub-steps of the same job

Bad:

```
def main():
    do_step_1()
def do_step_1():
    …
    do_step_2()
```

Good:

```
def main():
    do_step_1()
    do_step_2()

def do_step_1():
    do_step_1_part_1()
    do_step_1_part_2()
```

Reading this bad main, it looks like the program is just step1. Also (even worse), you can not run step1 without also running step2.

Do this now

Write a **complete** Python program following the standard structure that uses a `main` and a function similar to the print_line one we saw earlier, but that prints a line of random length up to the parameter passed in
E.g., `print_random_line(5)` would print a line of length 1-5.
Ask the user for a number then print a line up to that long.

Version 2: also ask for a number of lines to print and use a loop to print that many lines.

```
"""module-level docstring"""
import statements
CONSTANTS

def main():
    statements

def do_step_1()
    statements


def do_step_2()
    statements


main()
```

Name functions using verb phrases

```
age = get_age()
```

- `age` sounds like a *noun*, so it's a thing, so it's a *variable*
- `get_age` sounds like a *verb*, so it's a *function* that does something

- Good function names usually complete the sentence: *"This function will…"*
  - "This function will get_age" ☺
  - "This function will result_calc" ☹
  - "This function will determine_grade" ☺
  - "This function will value_check" ☹

Name functions using verb phrases

- A function's name should *say what it will do*
- Functions that return Booleans (True or False) are usually used as conditions, and should usually be named like **is_***

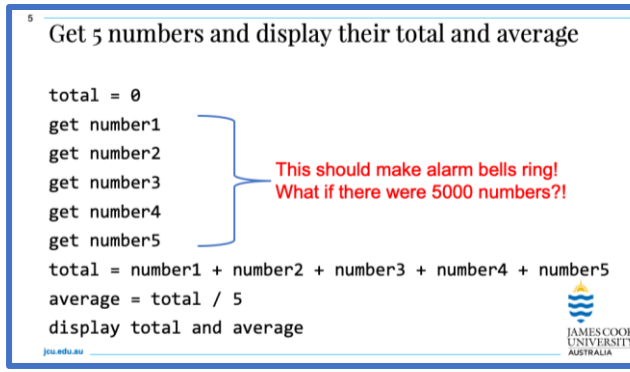
Purpose	Bad Names	Good Name
Determine if a temperature is hot	`hotness, how_hot, calculate_hot, hot...`	`is_hot`
Display a report	`report, calculate_report, results...`	`display_report`
Get a user's name	`name_getter, namey_mcname_face...`	`get_name`

Do this now

- Write good names for functions for the following tasks:
  1. determine a subject grade based on a given total score
  2. convert currency from USD to AUD
  3. print a report
  4. calculate the average of a list of numbers
  5. determine if a number is even
  6. get a user's salary, making sure that it is not negative

Functions can be used to "abstract" a task

- We very often have to write code that performs the same kind of task multiple times
- We already know there are disadvantages to duplicating code
  - Makes program large; can be time consuming; may need to make changes in many places…
- Some functions represent a task we want to perform multiple times but with slight differences
  - Calculating the area of a circle (of a given/different radius)
  - Converting values in one unit of measurement to another
  - Generating a random number between two values



Let's reconsider the age program from before

```
def main():
    age = get_age()
    if age < 18:
        print(f"At {age} years old, you are: child")
    elif age < 65:
        print(f"At {age} years old, you are: adult")
    else:
        print(f"At {age} years old, you are: geriatric")


def get_age():
    age = int(input("Age: "))
    while age < 0 or age > 150:
        print("Invalid age")
        age = int(input("Age: "))
    return age

main()
```

Is there another "task" here that we could use a function for?

Many functions do some kind of "processing"

- Remember where we started, with Input, Processing, Output?
- We might like to turn each step into a function (if it makes sense)
- Here, the processing step is determining an age category based on a person's age

```
if age < 18:
    print(f"At {age} years old, you are: child")
elif age < 65:
    print(f"At {age} years old, you are: adult")
else:
    print(f"At {age} years old, you are: geriatric")
```

But… the processing and output steps are combined

- We need to separate these two steps so that the processing step is a reusable function (**return** not print)

```
def determine_category(age):
    if age < 18:
        return "child"
    elif age < 65:
        return "adult"
    else:
        return "geriatric"
```

Now we have...

```
def main():
    age = get_age()
    category = determine_category(age)
    print(f"At {age} years old, you are: {category}")

def get_age():
    age = int(input("Age: "))
    while age < 0 or age > 150:
        print("Invalid age")
        age = int(input("Age: "))
    return age

def determine_category(age):
    if age < 18:
        return "child"
    elif age < 65:
        return "adult"
    else:
        return "geriatric"
```

What have we gained?

- We can focus our development efforts on one function at a time
- We can reuse these functions (in this or other programs)
  - get_age could be used anywhere we want a valid age
  - determine_category could be used for a ticket sales program with different prices per age category…
- We can read/understand the "whole program" (main) very quickly
  - We don't know all the details but we can see what it does overall

```
age = get_age()
category = determine_category(age)
print(f"At {age} years old, you are: {category}")
```

There are benefits to using functions

- Code can be reused
  - write the code (function) once and call it multiple times
- Testing and debugging is easier
  - Can test and debug each function individually
- Teamwork is easier
  - Different team members can write different functions
- Code is more readable (easier to understand)
  - Good names mean you can read the function header and know what it does
- Large programs can be developed faster

Do this now

1. Write a function that prints a string a certain number of times, where the string and the number of times are both input parameters (arguments)
    - Call it to print your first name 4 times
    - Call it to print "Hi" 17 times

2. Write a function to calculate the average of two numbers
    - Call it to work out the average of 7 and a user's age

Now do these next steps

- (Like we did with making coffee)
  Find an everyday process and think about breaking it down into functions - things that are sections or reusable tasks
- Practise writing programs that use functions
  - Go back to some of your earlier pracs and rewrite them with meaningful and well-named functions