

# Functions

*ENDG 233 – Programming with Data*

*Instructor: Dean Richert*



Introduction to programming  
Creating and running Python programs in JupyterLab  
Programming style  
Variables, operators, and basic data structures  
Flow control (if, else, for, etc.)



Advanced data structures  
Data manipulation  
Data visualization  
Algorithms

# Learning outcomes and outline

At the end of this lesson and accompanying active learning session you will be able to:

1. **Motivate** the use of functions in computer programming
2. **Define functions** in Python and the variants available
3. Call or **invoke functions** in Python
4. Understand some of the common **misconceptions** relative to Python functions, including the **distinction** between function definition and invocation
5. Apply your understanding of functions to decision-making using **machine learning**

# Introduction

**What** is a function?

Ans: A chunk or block of code that **receives** information, **performs** tasks, and **reports** results back



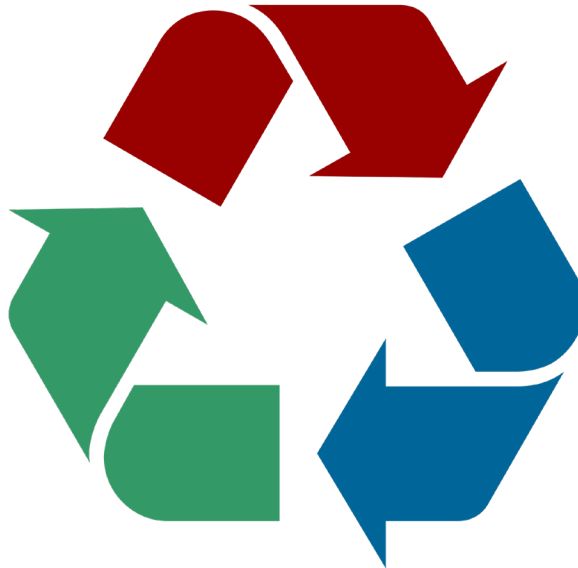
# Introduction

**Why** do we use function in programming?

**1. Code reuse**

2. Modularity

3. Readability



# Introduction

**Why** do we use function in programming?

1. Code reuse

**2. Modularity**

3. Readability



# Introduction

**Why** do we use function in programming?

1. Code reuse

2. Modularity

**3. Readability**

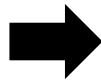
```
[1]: # Create a List of numbers
numbers = [5, 10, 15, 20, 25]

# Calculate the mean of the numbers
total = 0
for num in numbers:
    total += num
mean = total / len(numbers)

# Calculate the sum of the squared differences
sum_squared_diff = 0
for num in numbers:
    diff = num - mean
    squared_diff = diff ** 2
    sum_squared_diff += squared_diff

# Calculate the variance
variance = sum_squared_diff / (len(numbers) - 1)

# Calculate the standard deviation
std_deviation = variance ** 0.5
```



```
[4]: # Create a List of numbers
numbers = [5, 10, 15, 20, 25]
```

```
[5]: # Calculate the mean of the numbers
mean = calculate_mean(numbers)
```

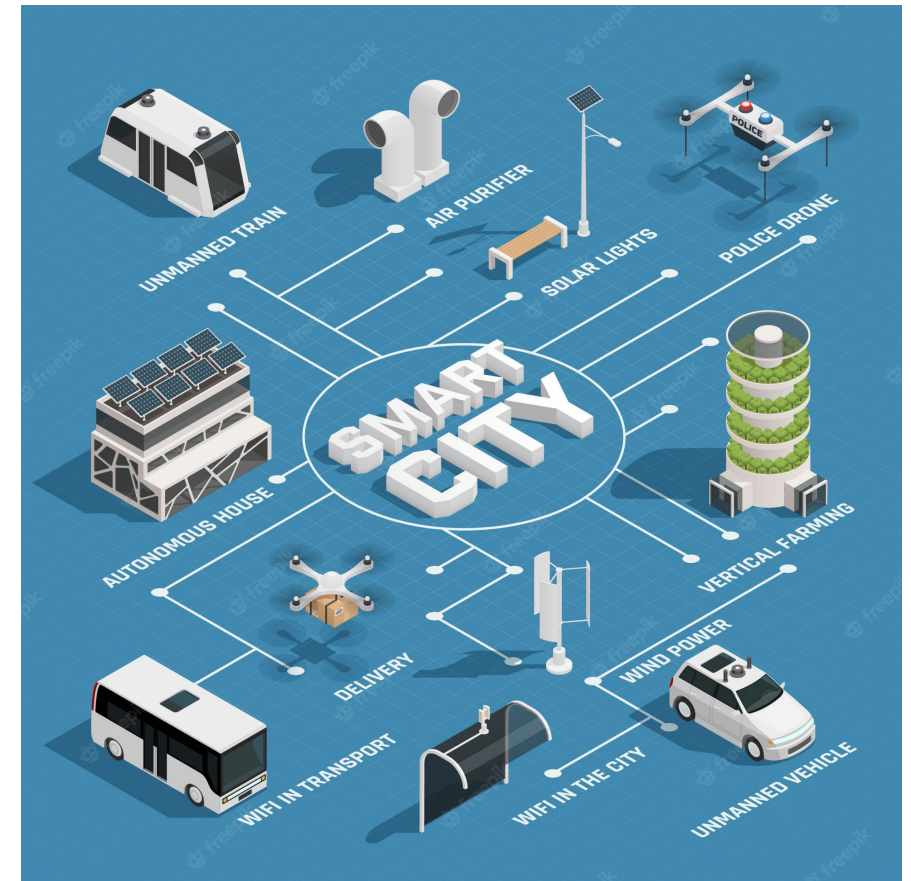
```
[6]: # Calculate the standard deviation
variance = calculate_variance(numbers)
```

# Introduction

Analogy of a function:



Engineering example:



# Function Definition

Functions must be defined **before** they can be used!



# Function Definition

Functions must be defined before they can be used!

**Anatomy** of a function definition:

```
[ ]: def function_name(<parameters>):  
    # Perform tasks here  
    return <data>
```

# Function Definition

Functions must be defined before they can be used!

**Anatomy** of a function definition:


```
[ ]: def function_name(<parameters>):  
    # Perform tasks here  
    return <data>
```

Function names should be lower case, meaningful, and have underscores to separate words

# Function Definition

Functions must be defined before they can be used!

**Anatomy** of a function definition:  
optional



```
[ ]: def function_name(<parameters>):  
    # Perform tasks here  
    return <data>
```

# Function Definition

Functions must be defined before they can be used!


**Anatomy** of a function definition:

```
[ ]: def function_name(<parameters>):  
    # Perform tasks here  
    return <data>
```

# Function Definition

Functions must be defined before they can be used!

**Anatomy** of a function definition:

```
[ ]: def function_name(<parameters>):  
     # Perform tasks here  
    return <data>
```

# Function Definition

Functions must be defined before they can be used!

**Anatomy** of a function definition:

```
[ ]: def function_name(<parameters>):  
    # Perform tasks here  
    return <data>
```



optional

# Function Definition - Example

```
[1]: def is_even(number):  
      print("determining if your number is even...")  
      if number % 2 == 0:  
          return True  
      else:  
          return False
```

# Function Invocation

Functions must be called/invoked to execute its code!

```
[1]: def add_numbers(a,b):  
      sum = a + b  
      return sum
```

```
[2]: add_numbers(2,4)
```

```
[2]: 6
```

```
[3]: num1 = 3  
      num2 = 5  
      result = add_numbers(num1,num2)  
      print(result + 7)
```

```
15
```

```
[4]: char1 = 'a'  
      char2 = 'b'  
      add_numbers(char1,char2)
```

```
[4]: 'ab'
```



# Function Invocation

Functions must be called/invoked to execute its code!

```
[1]: def add_numbers(a,b):  
      sum = a + b  
      return sum
```

```
[2]: add_numbers(2,4)
```

```
[2]: 6
```

```
[3]: num1 = 3  
      num2 = 5  
      result = add_numbers(num1,num2)  
      print(result + 7)
```

```
15
```

```
[4]: char1 = 'a'  
      char2 = 'b'  
      add_numbers(char1,char2)
```

```
[4]: 'ab'
```

# Function Invocation

Functions must be called/invoked to execute its code!

```
[1]: def add_numbers(a,b):  
      sum = a + b  
      return sum
```

```
[2]: add_numbers(2,4)
```

```
[2]: 6
```

```
[3]: num1 = 3  
      num2 = 5  
      result = add_numbers(num1,num2)  
      print(result + 7)
```

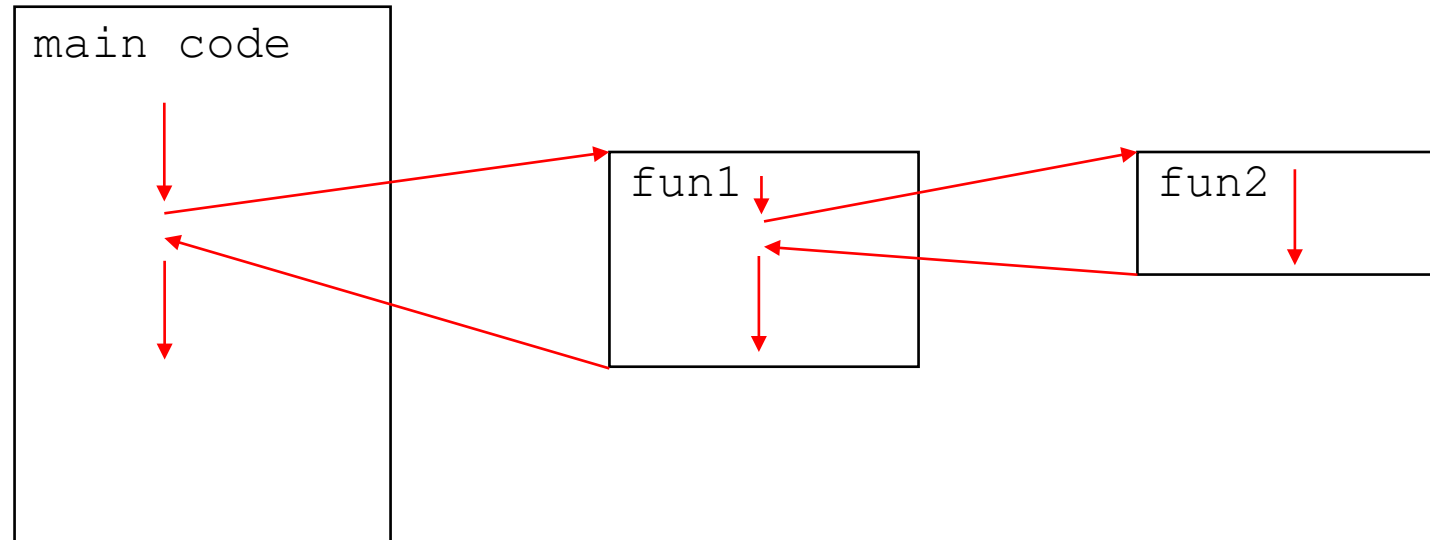
```
15
```

```
[4]: char1 = 'a'  
      char2 = 'b'  
      add_numbers(char1,char2)
```

```
[4]: 'ab'
```

# Function Invocation

Functions can call other functions (or even themselves)



# Function Invocation

Functions can call other functions (or even themselves)

$$S^2 = \frac{\sum (x_i - \bar{x})^2}{n - 1}$$

```
[1]: def calculate_mean(numbers):  
      # Calculate the mean of the numbers  
      total = 0  
      for num in numbers:  
          total += num  
      mean = total / len(numbers)  
      return mean
```

```
[2]: def calculate_variance(numbers):  
      sum_squared_diff = 0  
      for num in numbers:  
          diff = num - calculate_mean(numbers)  
          squared_diff = diff ** 2  
          sum_squared_diff += squared_diff  
      variance = sum_squared_diff / (len(numbers) - 1)  
      return variance
```

```
[3]: calculate_variance([5, 10, 15, 20, 25])
```

```
[3]: 62.5
```

# Advanced topics

## Multiple return values

```
[3]: def get_statistics(data):  
      mu = calculate_mean(data)  
      var = calculate_variance(data)  
      return mu, var
```

```
[4]: mu, var = get_statistics([1,2,3,4,5])
```

```
[5]: _, var = get_statistics([1,2,3,4,5])
```

# Advanced topics

## Multiple return values

```
[3]: def get_statistics(data):  
      mu = calculate_mean(data)  
      var = calculate_variance(data)  
      return mu, var
```

```
[4]: mu, var = get_statistics([1,2,3,4,5])
```

```
[5]: _, var = get_statistics([1,2,3,4,5])
```

# Advanced topics

**Keyword arguments** allow parameters to be sent out of order

```
[1]: def machine_status(pressure, temperature):  
      if pressure > 65 or temperature > 220:  
          print("warning")  
      else:  
          print("normal")
```

```
[2]: machine_status(60, 200)
```

normal

```
[3]: machine_status(temperature = 200, pressure = 60)
```

normal

# Advanced topics

**Default argument values** allow parameters to be omitted

```
[1]: def machine_info(serial_no, mfg = "Haas"):
      if serial_no[0] == '1':
          print("This is a " + mfg + " machine from before 2010")
      else:
          print("This is a " + mfg + " machine from 2010 or after")
```

```
[2]: machine_info("123", "Fanuc")
```

This is a Fanuc machine from before 2010

```
[3]: machine_info("234")
```

This is a Haas machine from 2010 or after



# Resources

- Programming with Mosh YouTube channel – [Python Functions](#) video
- W3Schools [Python Functions](#) page
  - For further study:
    - Arbitrary Arguments (`*args`)
    - Arbitrary Keyword Arguments (`**kwargs`)
    - `pass` statement
    - Recursion
- [chatGPT](#) to help with debugging or generating sample code

# TA Training

## Expectations:

- Circulate among the groups to ensure that they are on the right track and answer any questions they may have.
  - Make sure you visit every group, but manage your time to keep all groups at the same pace.
- Engage the group in discussion, asking them comprehension checking questions.
- Students should not be using their phones or computers for unrelated activities. Let the instructor know if students are not engaging in the ALS.

Solutions: <https://github.com/deanmrichert/functions> ALS TAresources

# Active Learning Session – Getting Started



1. Download the JupyterLab Notebook from <https://bit.ly/3K6MSGr>

A screenshot of a GitHub repository page for 'functions\_ALS\_decisionTree'. The repository is public and has one branch, 'main'. The page shows two files: 'functions\_ALS\_decisionTrees.ipynb' and 'functions\_ALS\_decisionTrees\_soln.ipynb'. A red circle highlights the 'Code' button in the top right corner. A red arrow points from the 'Code' button to the 'Download ZIP' button, which is also circled in red. A red arrow points from the 'Download ZIP' button to a box labeled 'Extract' containing the filename 'functions\_ALS\_decisionTrees.ipynb'.

functions\_ALS\_decisionTree Public

main 1 branch 0 tags

deanmrichert Add files via upload

functions\_ALS\_decisionTrees.ipynb Add files via upload

functions\_ALS\_decisionTrees\_soln.ipynb Add files via upload

Help people interested in this repository understand your project by adding

Local Codespaces New

Clone

HTTPS SSH GitHub CLI

[https://github.com/deanmrichert/functions\\_ALS](https://github.com/deanmrichert/functions_ALS)

Use Git or checkout with SVN using the web URL.

Open with GitHub Desktop

Download ZIP

**Extract**

functions\_ALS\_decisionTrees.ipynb

# Active Learning Session – Getting Started



2. Open the web-based JupyterLab from <https://bit.ly/3NYUtc9>

The screenshot shows the JupyterLab web interface. On the left is a file browser pane with a search bar and a list of files: 'Intro.ipynb', 'Lorenz.ipynb', and 'sqlite.ipynb', all modified 'a month ago'. Below the list is a '+ Copy' button. A red arrow points from this button to a file explorer window overlaid on the right. The file explorer window shows a directory tree with 'functions\_ALS\_decisionTrees' selected and circled in red. The main area of JupyterLab is titled 'Launcher' and displays a grid of application tiles: 'Notebook', 'Python (Pyodide)', 'SQLite', and 'Console'. The bottom status bar shows 'Simple' mode, a toggle switch, and resource usage: '0 \$ \_ 0'.

# Active Learning Session – Getting Started

## 3. Basic idea behind JupyterLab:

```
[3]: print("Hello World")
```

```
Hello World
```

```
[2]: a = 1  
b = 2  
a + b
```

```
[2]: 3
```

```
[1]: print("Did this run first?")
```

```
Did this run first?
```

- Code cells are standalone chunks of code
- Code cells can be executed in any order, not just the order they appear
- The order in which code cells are executed are shown in square brackets [\*] to the left of code cells
- Outputs appear below code cells and can be cleared by right-clicking on a cell and selecting “Clear Outputs”

# Active Learning Session – Getting Started

## 4. General instructions for using JupyterLab

The screenshot shows the JupyterLab interface. On the left is a file browser with a search bar and a table of files. The main area displays a notebook titled 'functions\_ALS\_decisionTrees.ipynb'. Three red circles highlight icons in the notebook toolbar: a plus sign, a play button, and a circular arrow. Red arrows point from these icons to text boxes: 'Insert new code cell', 'Execute code cell', and 'Reset the project'.

**File Browser:**

Name	Last Modified
functions_A...	12 minutes ago
Intro.ipynb	a month ago
Lorenz.ipynb	a month ago
sqlite.ipynb	a month ago

**Notebook Toolbar:**

- Insert new code cell:** Indicated by a red circle around the '+' icon.
- Execute code cell:** Indicated by a red circle around the play button icon.
- Reset the project:** Indicated by a red circle around the circular arrow icon.

**Notebook Content:**

### Background - Decision Trees

Decision trees are a machine learning technique used for classification or regression tasks. Classification, which is the focus of this ALS, refers to labelling an input as a member of a particular class. The goal is to label a machine as "needing maintenance" or "not needing maintenance" based on measurements from various sensors.

Decision trees have an intuitive flowchart-like structure where each node represents a feature, each branch represents a decision, and each leaf node represents an outcome or prediction. This is illustrated in the figure below which shows a decision tree that was trained to identify whether a point  $(x_1, x_2)$  is part of the red class or the blue class [1].