WEEK 1: INTRODUCTION TO MATLAB 🎉

OBJECTIVES:

- Get familiar with MATLAB's interface and basic commands.
- Learn how to think like a programmer (algorithmic thinking 🧠).
- Start creating your own mini-programs to solve cool problems!

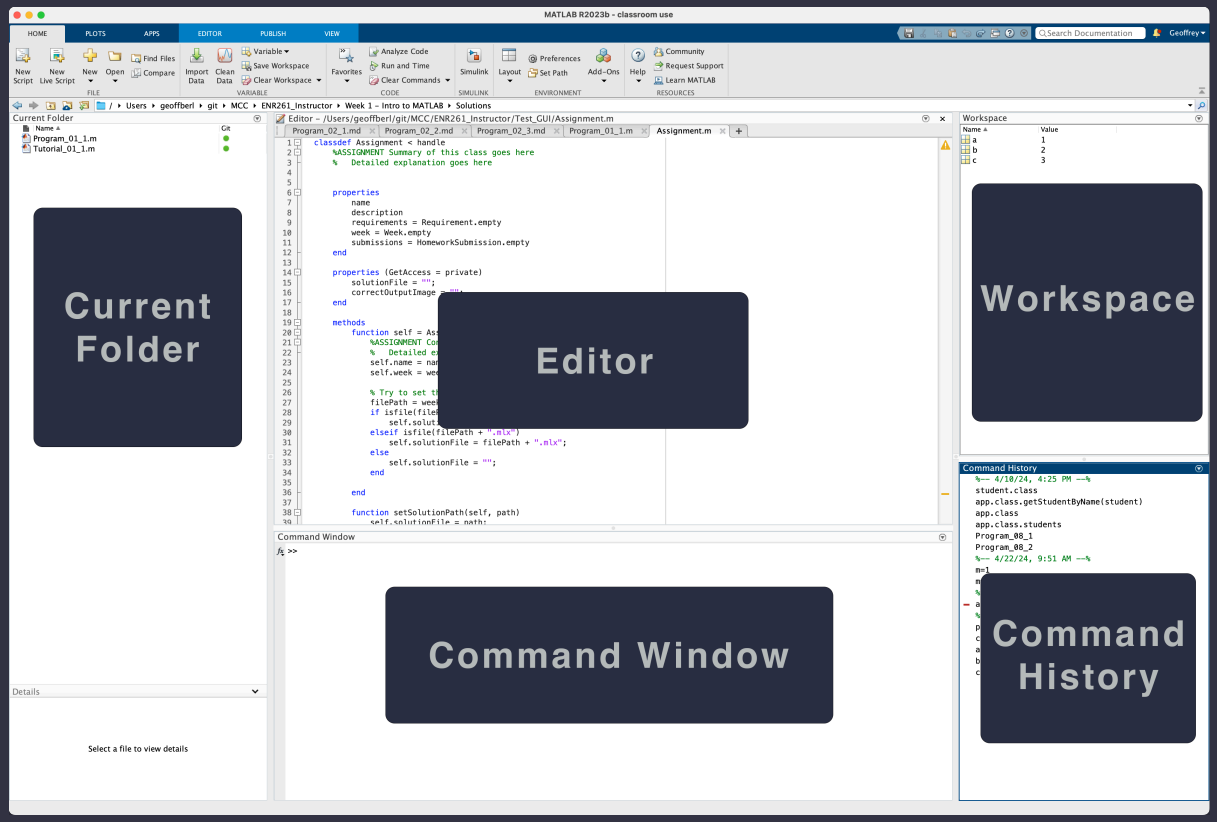
INTRODUCTION TO THE MATLAB INTERFACE

WHAT IS MATLAB?

- MATLAB was originally developed for matrix calculations.
- It is useful to engineers and scientists for data analysis and solving complex problems.

THE MATLAB DESKTOP INTERFACE

- **Command Window**: Where you type commands and see immediate results.
- **Workspace**: Displays variables you've created during your session.
- **Command History**: Keeps a record of the commands you've entered.
- **Editor**: Used for writing scripts (M-files) and functions.
- **Current Folder**: The current working directory (`cwd`).



INTERACTIVE DEMONSTRATION:

- Open MATLAB and take a tour of the interface.
- Feel free to open MATLAB and follow along.

HANDY SHORTCUTS ⌨️

- Command Window history: ↑ / ↓
- Auto-complete: tab
- Stop execution: ctrl + c
- Editor: Run section or file via toolbar (or *Run* button)
- Comment/Uncomment selection (Editor toolbar)

CREATING A SCRIPT (.M) 📝

1. In MATLAB, click "New Script" (Home tab → New → Script)
2. Type your code in the Editor; add comments with `%`
3. Save as `my_script.m` (avoid names that shadow functions, e.g., `mean.m`)
4. Run via the green Run button (or right-click → Run)
5. Keep the script in the Current Folder or on the MATLAB path

Tips:

- End lines with `;` to suppress output
- Use code sections with `%%` to run blocks independently
- Scripts share the base workspace; functions have their own workspace

EXAMPLE SCRIPT: HELLO_WORLD.M

```
% HELLO_WORLD  Demo script that creates data and plots it
clc; clear; close all;

%% Parameters
t = 0:0.1:10;           % time vector
A = 2; f = 0.5;        % amplitude and frequency

%% Compute signal
y = A * sin(2*pi*f*t);

%% Plot
plot(t, y, 'LineWidth', 1.5); grid on;
xlabel('Time (s)'); ylabel('Amplitude');
title('Sine Wave');
```

Common errors to avoid:

- Script name conflicts (e.g., `plot.m` will break the built-in `plot`)
- Saving the script outside the Current Folder (not on path)
- Accidental workspace reuse; if behavior seems odd, try `clear` and re-run

THE COMMAND WINDOW 💻

USED FOR REAL-TIME INTERACTION:

- MATLAB allows you to interact directly with your data. For example, typing `2 + 3` and pressing `enter` will immediately return `ans = 5`.

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💡 Tip:

`clc` → `Cl`ear `C`ommand Window

`clear` → `Cl`ear `E`nvironment

INTERACTIVE EXERCISE:

1. Open MATLAB.
2. Try the following commands and observe:

```
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whos
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3. What happened after each command?

💡 Tip: More on Commands

- Use ↑ to cycle through previously executed commands. (works better without the history window)
- Double-click or drag and drop from the command history window (may need to be enabled).
- Start typing a previously used command and use ↑ to filter
- Start typing a known command and use tab to see possible solutions
- ctrl + c: Stops the execution of a command or script if it runs too long or seems to be stuck.

DEBUGGING BASICS 🐞

- Set a breakpoint: click the left gutter next to a line in the Editor
- Run your script: execution stops at the breakpoint
- Step Over / Step In / Continue using the Debug toolbar
- Inspect variables in the Workspace; hover in the Editor to see values
- Stop debugging or remove breakpoints when done

Tip: Add a temporary `disp()` to print variables while you iterate.

ANALOGY: DEBUGGING 🎬

- Breakpoints are pause points in a video
- Step Over = advance one frame; Step In = open the scene (function)
- Workspace is your on-screen overlay showing live values

LEARNING AND EXECUTING SIMPLE COMMANDS

COMPUTATION NOTATION:

- MATLAB uses standard mathematical operators: `+`, `-`, `*`, `/`, `^`.
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```

```
3 * 2
```

```
3 / 2
```

```
3 ^ 2
```

```
1 + inf
```

VARIABLES 🥣

WHAT ARE VARIABLES?

- Variables are like labeled jars: the *label* is the variable name and the *contents* are the value.
- Replacing the contents does not change the label (name stays the same).
- The Workspace is your pantry where all the jars (variables) live. Clearing the workspace empties the pantry.

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"This jar is a **double**, and it currently contains **42**."

STANDARD NAMING CONVENTIONS

- `camelCase`
- `snake_case`
- `ALL_CAPS`, `SCREAMING_SNAKE_CASE`

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Example:

```
MAX_FRUIT_ALLOWED = 15
numApples = 5
numOranges = 10
fruitCount = a + b
withinLimit = fruitCount <= MAX_FRUIT_ALLOWED
```

SCRIPT VS FUNCTION 👩‍🍳⚙️

- Script = Recipe in the main kitchen (base workspace)
  - Uses whatever is on the counter unless you clean first (`clear`)
  - No inputs/outputs by signature; affects current Workspace
- Function = Kitchen appliance with its own chamber (private workspace)
  - Put inputs in, get outputs out; does not see your counters
  - Safer, reusable, testable

IMPORTANT CONCEPTS:

- **Case Sensitivity**: `Variable` and `variable` are different.
- **Naming Conventions**: Stick to clear, descriptive names to make your code easier to understand.

RESERVED WORDS/VARIABLES:

- MATLAB has predefined variables, known as constants, like `pi` and functions like `inf`.
- MATLAB also has predefined functions, such as `sin`, `cos`, `clear`, `clc`, `sqrt`, etc.

Warning! Avoid using reserved names for your variables when possible.

ANALOGY: MATRICES & TABLES 📊

- Matrix = Excel grid (rows × columns). Example: `A(2:4,1:3)` ↔ cells A2:C4
- Table = Spreadsheet with headers (named columns) and typed values
- Add a column = add a new header; add a row = add a new record
- Use tables when names/units matter; use matrices for pure numeric work

ALGORITHMS

WHAT IS AN ALGORITHM?

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Put simply, an algorithm is a set of instructions to complete a task or solve a problem.

ALGORITHM DEVELOPMENT PROCESS 🗺️

1. **Analyze the problem** – Just like planning a trip, figure out where you want to go.
2. **Define inputs** – Pack your bags! What do you need to go on your trip?
3. **Perform Manipulations** – Map out your route, how are you going to get there?
4. **Produce Output(s)** – Arrive at your destination!

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BEST PRACTICES:

- **Commenting**: Use comments (%) to explain your code. This helps others (and future you) understand what your code does.
- **Incremental Development**: Write and test small pieces of code before integrating them into a larger program.

PROBLEM SOLVING EXAMPLE: VOLUME OF A CONE

APPLYING WHAT WE'VE LEARNED:

1. **Analyze the problem**: Explain the formula $v = \frac{\pi r^2 h}{3}$
2. **Define inputs** (in this case variables):

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```
radius = 6
height = 12
```

Note: *We don't need* `pi` *as that's provided for us*

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3. **Perform the manipulation**:

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volume = (pi * radius^2 * height) / 3
```

4. **Produce Output/Result**:

   In this case, we are simply outputting to `volume` and the console (done by MATLAB)

INTERACTIVE EXERCISE:

LET'S COMPUTE THE VOLUME OF A CONE:

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```
radius = 7
```

```
radius =

        7
```

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LET'S COMPUTE THE VOLUME OF A CONE:

```
radius = 7
```

```
radius =

        7
```

```
height = 10
```

```
height =

        10
```

INTERACTIVE EXERCISE:

LET'S COMPUTE THE VOLUME OF A CONE:

```
radius = 7
```

```
radius =

        7
```

```
height = 10
```

```
height =

        10
```

```
volume = (pi * radius^2 * height) / 3
```

```
volume =

        513.1268
```

INTRODUCTION TO M-FILES

WHAT ARE M-FILES?

- M-files are scripts or functions you can save and reuse. They help organize code and are essential for more complex projects.

USED FOR:

- Saving your programs (scripts).
- Executing a list of commands.
- Saving your work while you work through a problem.
- Re-opening and modifying your program at any time.

CREATING A BASIC M-FILE:

1. Open the MATLAB Editor.
2. Choose "New Script" from the menu
3. Type the following:

```
% Compute and display the volume of a cone
radius = 6
height = 12
volume = (pi * radius^2 * height) / 3
```

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4. Save as `volume_of_cone.m`.

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2. Choose "New Script" from the menu
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```
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radius = 6
height = 12
volume = (pi * radius^2 * height) / 3
```

4. Save as `volume_of_cone.m`.
5. Run the script by typing `volume_of_cone` in the Command Window.

MORE ON SCRIPTS:

- To run a MATLAB script call the filename without `.m`
- The script must be in the current working directory `cwd`
- Alternatively, you can provide a path (`C:\my\script\location.m`)

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OUTPUT SUPPRESSION:

- MATLAB, by default, prints command results to the command window.
- When someone asks for the volume of a cone, they probably don't want to see the radius, and height displayed.
- We can use the semicolon `;` operator to *suppress* output.

UPDATING OUR SCRIPT

- We'll add some semicolons to suppress the output of redundant values.

```
% Compute and display the volume of a cone
radius = 6;
height = 12;
volume = (pi * radius^2 * height) / 3
```

SUPPRESSING OUTPUT & DISPLAYING RESULTS

In MATLAB, a semicolon `;` at the end of a line suppresses output. But what if you want to display something?

- **disp(variable)**: A quick way to show the value of `variable` in the Command Window.
- **fprintf(format, variables...)**: For formatted output, similar to `printf` in C.

```
% Example of using disp vs. fprintf

radius = 6;
height = 12;
volume = (pi * radius^2 * height) / 3;  % Volume of a cone

% Quick display:
disp(volume)

% Formatted display:
fprintf('The volume of the cone is %.2f cubic units.\n', v
```

CREATING QUALITY WORK:

- Write clear and understandable code.
- Add comments to document your code.
- Include a set of header comments with the program's objective, your name, anyone who assisted you.

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TIP! Write your comments first, then write code to honor your comments.

EXAMPLE PROGRAM WITH EXPECTED FORMAT

```
% Compute and display the volume of a cone
%
% Filename: Volume_of_cone
% Developer: Your Name
% Assisted By:
% Date: 08/04/2024

% Always start with a clean output and workspace
clc
clear

% Declare variables
radius = 6; % Radius of the cone (inches)
height = 12; % Height of the cone (inches)

% Compute the volume of a cone
volume = (pi * radius^2 * height) / 3;
```

ERROR HANDLING AND DEBUGGING 🕵️

BE THE DETECTIVE!

- **Syntax Errors**: Oops, you mistyped something! Let's fix it.
- **Runtime Errors**: Something went wrong during the run – let's figure out why!

INTERACTIVE EXERCISE:

Run `clear` and introduce an error by changing `radius` to `radiuss` in the M-file and let's observe the error message.

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TIP! Start fresh to avoid confusion.

- Whenever you run into a problem like this it is a good idea to `clear` your workspace of any possible bad values.
- You should include `clear`, and sometimes `clc` in your script to ensure you are starting fresh.

USING THE HELP SYSTEM

ACCESSING MATLAB HELP:

- **In Command Window**: Type `help` enter to get information on a specific command.
- Right-click on a function and select "Help on `functionName`".
- **Help Browser**: Access via the  icon.

Example:

- Type `help sin` to explore how MATLAB handles trigonometric functions.

GENERAL SHORTCUT TIPS

KEYBOARD NAVIGATION:

- home and end keys jump to the beginning and end of the line (cmd + ← / → on Mac).
- Arrow keys move a single character (← / →) or row (↑ / ↓).
- ctrl + ← / → jumps by word (option + ← / → on Mac).
- Holding shift while moving the cursor (using any of the aforementioned shortcuts), selects text.
- ctrl + c to copy, or ctrl + x to cut, ctrl + v to paste. (cmd + c, cmd + x, cmd + v on Mac)
- Double-click highlights a word, triple-click highlights a row.

LECTURE RECAP

- Variables are used for storing data for re-use.
- Use clear, and informative names.
    - Others and future-you will thank you
- M-files allow you to save and organize your work.
- The command window is immediate and can allow you to troubleshoot, or incrementally develop your code.
- Use Help whenever you're unsure of a command's syntax or usage.
- **Always**:
    - Write clear, well-documented code.
    - Include **comments**. (This is your documentation)
    - **Suppress** what doesn't need to be displayed.
    - Start with a `clear` workspace and `clc`d command window.
    - Learn keyboard shortcuts for efficient coding.
    - Save often, commit often.

GOTCHAS

- Variables **are** case sensitive, do not try to use this to your advantage.
- Don't forget `;` to suppress undesirable output.
- Be careful not to overwrite (mask) reserved variables/names.
- Copy and paste is your frienemy.

ANALOGIES:

- **MATLAB Interface**: Think of MATLAB as a sophisticated calculator with a built-in notebook where you can save your calculations and notes.
- **Command Window**: Imagine MATLAB M-files (scripts) as a solution to a math problem. The Command Window is like your calculator where you check your values and help you develop your scripts.
- **Variables**: Think of variables as labeled containers. You store information in them, which you can use later.
- **M-Files**: M-files are like recipes; they list the steps needed to perform a task. You can save them, modify them, and share them with others.

SOFTWARE ENGINEERING EXAMPLE