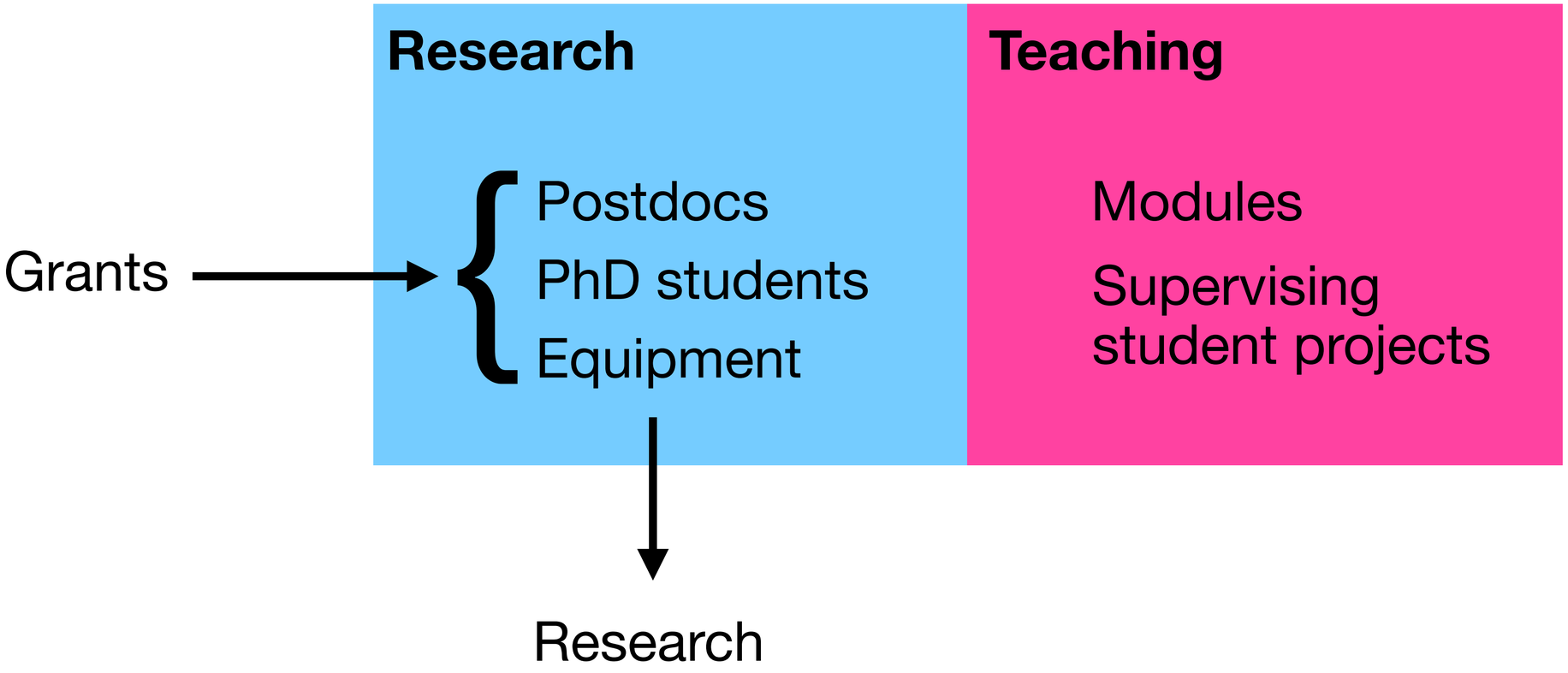
Learning how to think mathematically and computationally

(Mathematics and Computational Methods for Complex Systems, 2023-2024)

Dhruva V. Raman & Fernando Andracas

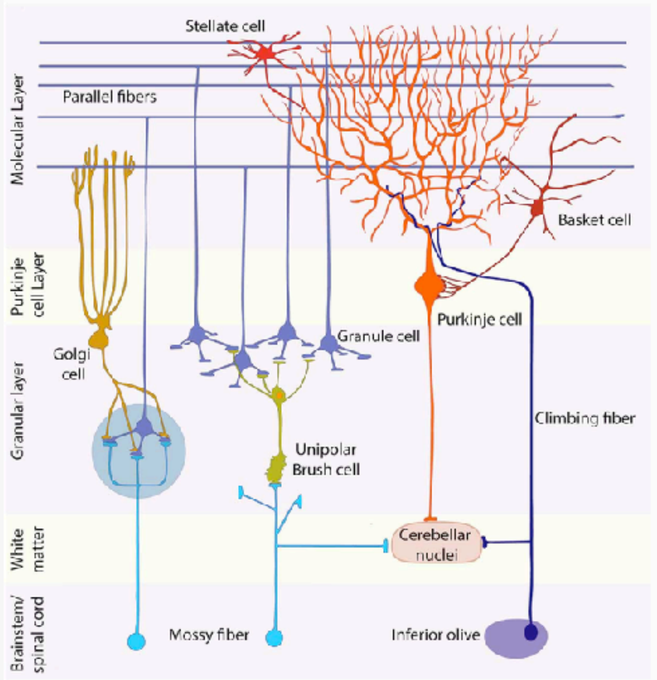
Who are we? A lecturer's life



Dhruva / ~~Sir~~ / ~~Professor~~

(Don’t worry about correct pronunciation)

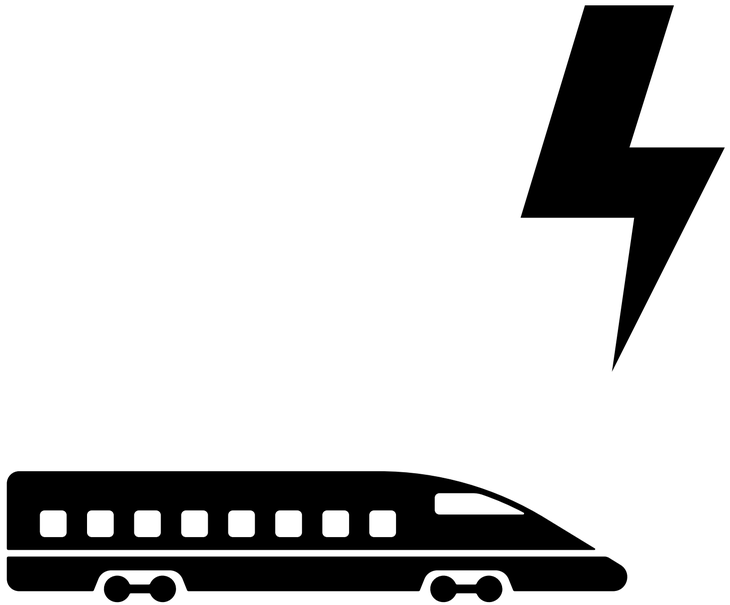
Design principles in biological systems



What about this design makes this system good for function?

Can we better understand function from design?

Fernando



Who are you?

Diverse academic backgrounds.
That’s ok!

Making a spectrum of friends will help you academically and personally

- Introduce yourself to neighbours each lecture
- Don’t sit in the same places each week!

Learning goal: how to digest maths

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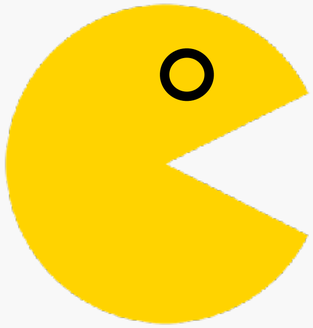
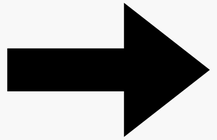
21st century life





How to learn/communicate/use/think with mathematical concepts

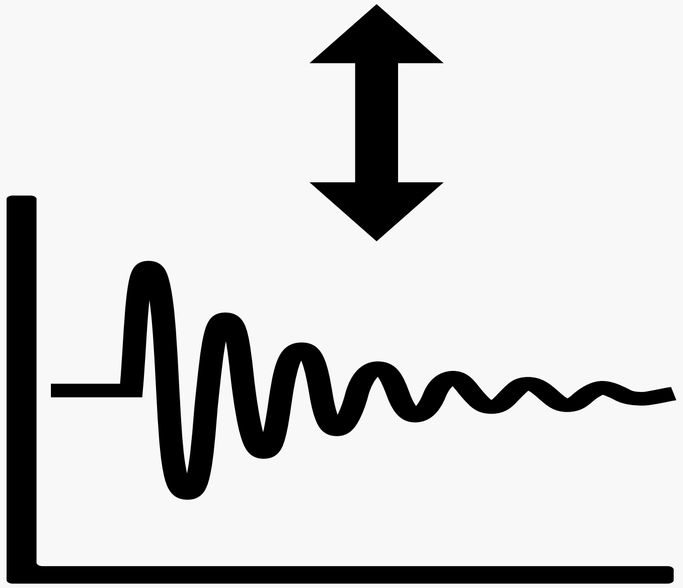
By learning maths!

Learn maths all of it!

Requirement 1: Language

Definition of a continuous function

$$\forall \epsilon \in \mathbb{R}^+ : \quad \exists \delta > 0 \text{ s.t.}$$
$$\|x - y\|_2 < \delta \Rightarrow \|f(x) - f(y)\|_2 < \epsilon$$



Mathematics

Reading/writing using LaTeX notation

Appreciating/using good grammar

https://kapeli.com/cheat_sheets/LaTeX_Math_Symbols.docset/Contents/Resources/Documents/index

Requirement 1: Language

Definition of a continuous function

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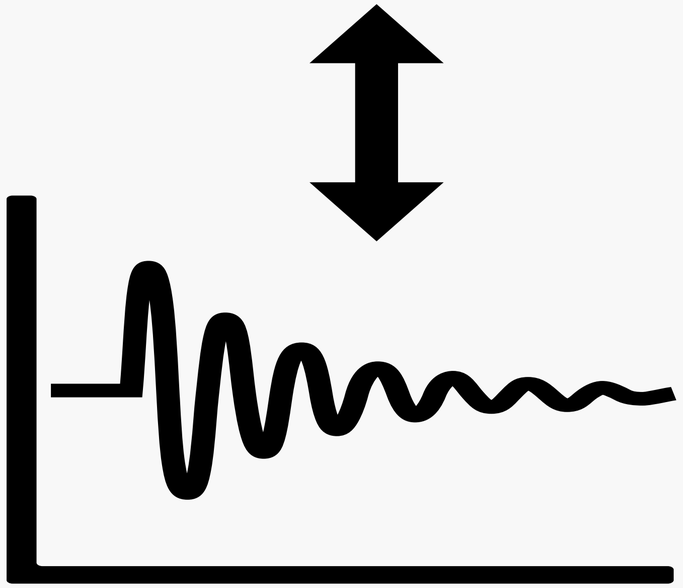

Mathematics **+ programming**

Reading/writing using LaTeX notation

Appreciating/using good grammar

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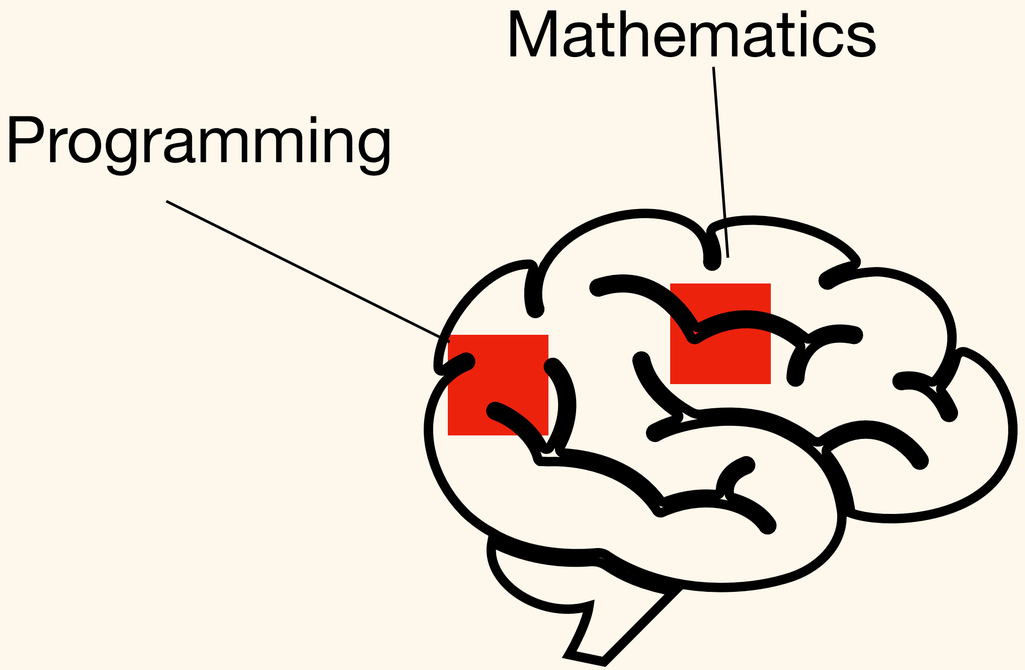
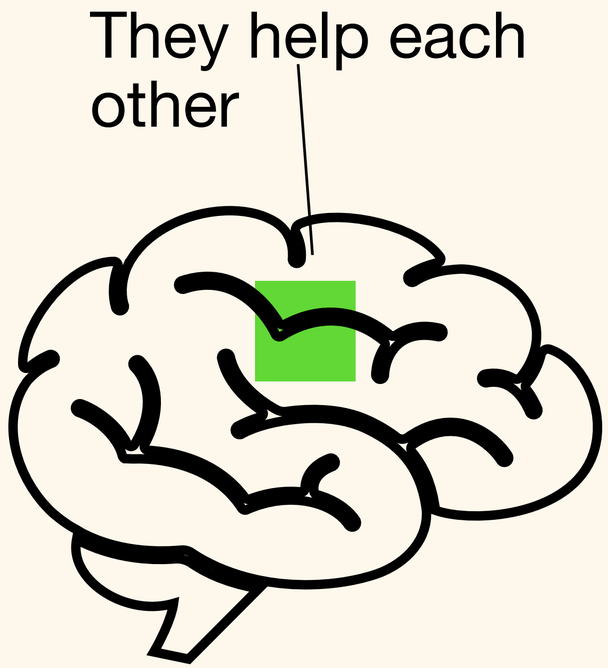
Requirement 2:

Unifying mathematical and computational thinking

Bad

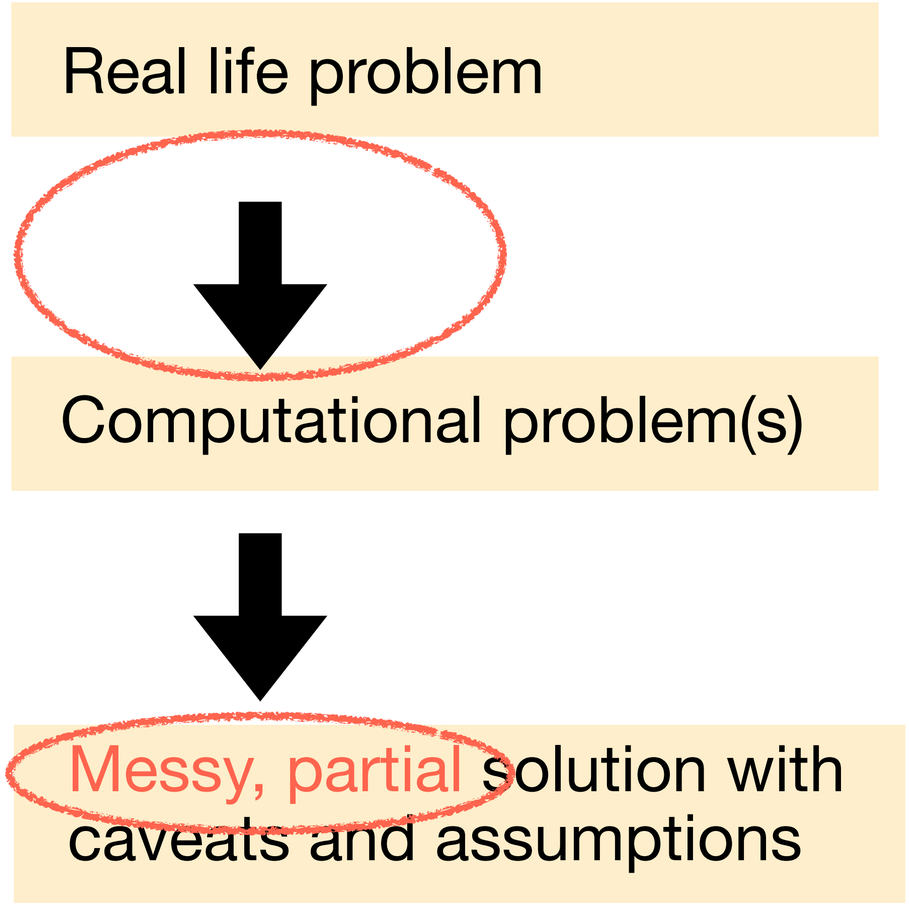


Good



Requirement 3:

Maths as a pragmatic tool for complex systems



Worried?

https://algorithmic-approaches-to-mathematics.github.io/prerequisites/

Maths is not a spectator sport!!!!

Maths is not a spectator sport!!!

Attend all lectures

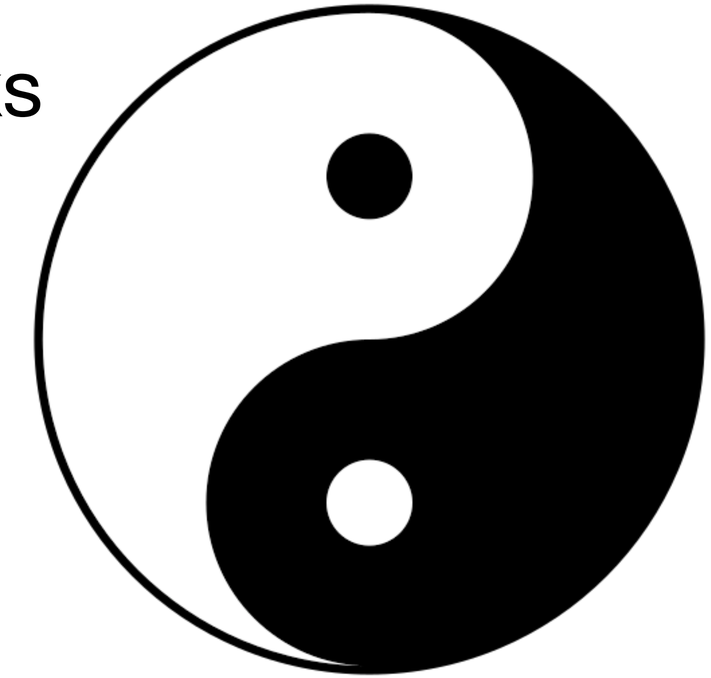
Read and understand all worksheets

Revise all concepts

} FAIL THE EXAM

Course structure

Pluto notebooks
that you fill in



(Lectures)

Pluto.jl

Welcome to MCMCS!!

Week 1: Assignment, logic, and functions

Goals of this worksheet

- Start getting comfortable with using basic Julia to express maths.
- Familiarise yourself with Pluto notebooks and LaTeX shortcuts for writing mathematical symbols.
- Introduction to the type system in Julia. (All languages have one, implicitly or explicitly)

First make sure you can...

- add your own code / text boxes.
- enable and hide visibility of the code by clicking the eye on the top left corner of each code box.
- modify existing code / text. EG what you are reading right now. Look at how I made this box textual: md followed by three quotation marks, and ended by three quotation marks. This creates a text box where you can write in markdown. Google markdown syntax, eg here. Notice that you can freely alter this box itself! **Try it**
- use the live docs to help you see the definition of the code you are writing
- modify and save the worksheet
- write maths using dollar signs and LaTeX syntax, e.g. by modifying the equation below. Notice the dollar signs have to be touching the maths...no spaces! Learning LaTeX syntax will be an ongoing exercise, **necessary for the exam**, over the next few weeks.

$$x^2 + y^2 = \frac{a}{b} + \int_1^3 \gamma(t)\, dt$$

- note that **comments** can be made in code blocks using the comment icon #. Comments don't affect the code. You will see commented code below.

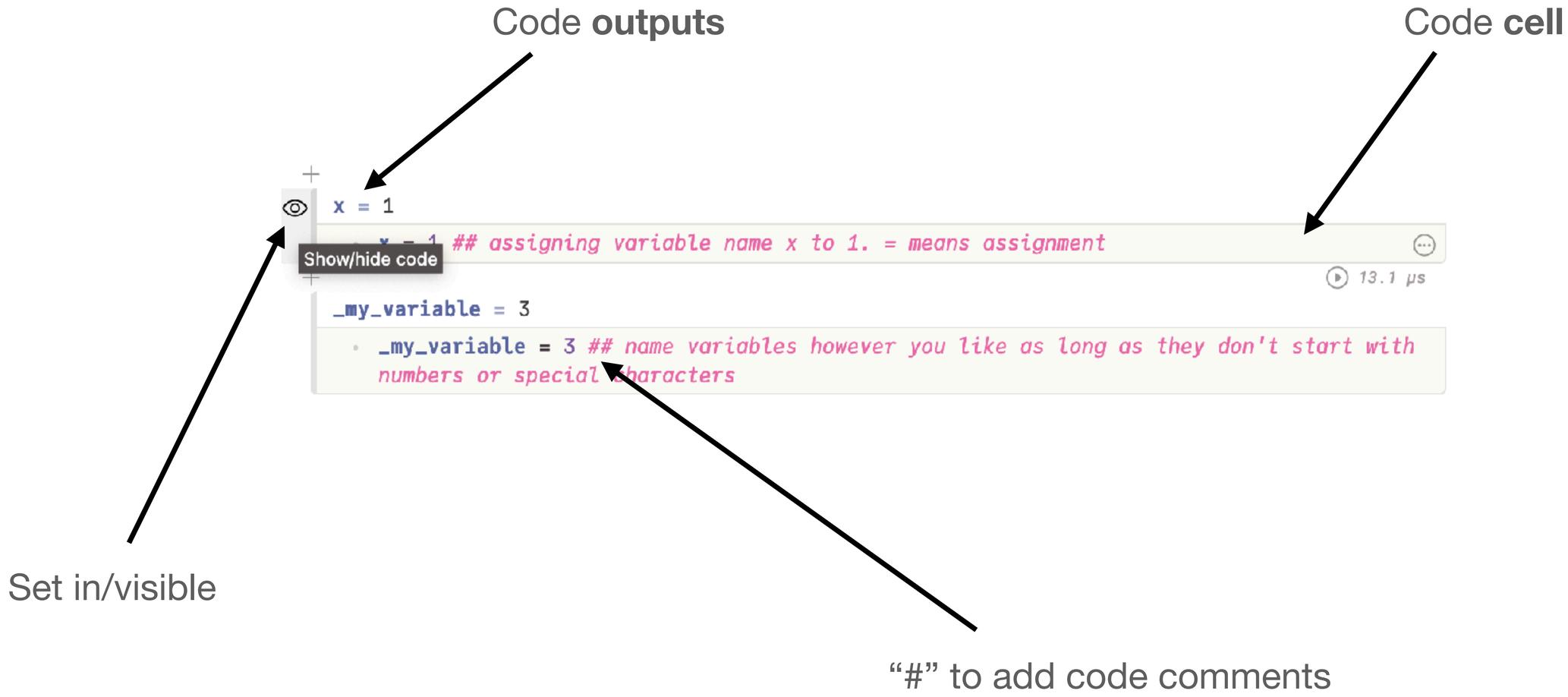
Repeat before each lab

This is my notebook. There are many like it,
but this one is mine

My notebook is my best friend. It is my life.
I must master it as I must master my life.

Without me, my notebook is useless.
Without my notebook, I am useless

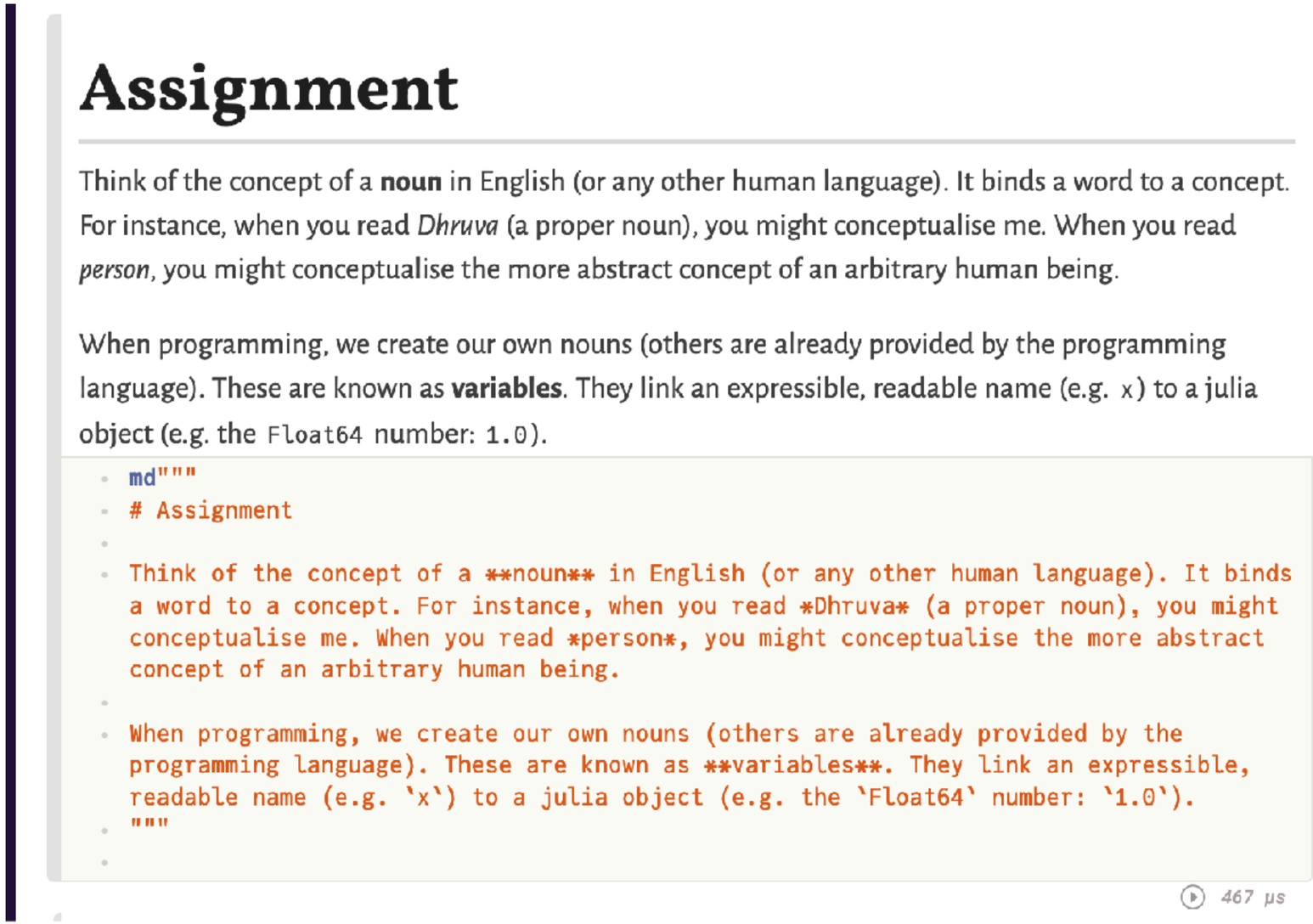
Code blocks


Code **outputs**
Code **cell**
x = 1
x = 1 ## assigning variable name x to 1. = means assignment
Show/hide code
13.1 µs
_my_variable = 3
_my_variable = 3 ## name variables however you like as long as they don't start with numbers or special characters
Set in/visible
"#" to add code comments

Code blocks
in markdown

> # Assignment
>
> Think of the concept of a **noun** in English (or any other human language). It binds a word to a concept. For instance, when you read *Dhruva* (a proper noun), you might conceptualise me. When you read *person*, you might conceptualise the more abstract concept of an arbitrary human being.
>
> When programming, we create our own nouns (others are already provided by the programming language). These are known as **variables**. They link an expressible, readable name (e.g. `x`) to a julia object (e.g. the `Float64` number: `1.0`).

Code blocks
in markdown



www.markdownguide.org/basic-syntax/

Writing LaTeX in markdown

This is a nonsensical mathematical expression

$$\int_0^T \frac{a(t)}{b(t)} \mathrm{d} t \in \mathbb{R}$$

- []e

```
md"""

##### This is a nonsensical mathematical expression

$$\int_{0}^T \frac{a(t)}{b(t)} \mathrm{d} t \in \mathbb{R}$$


"""
```

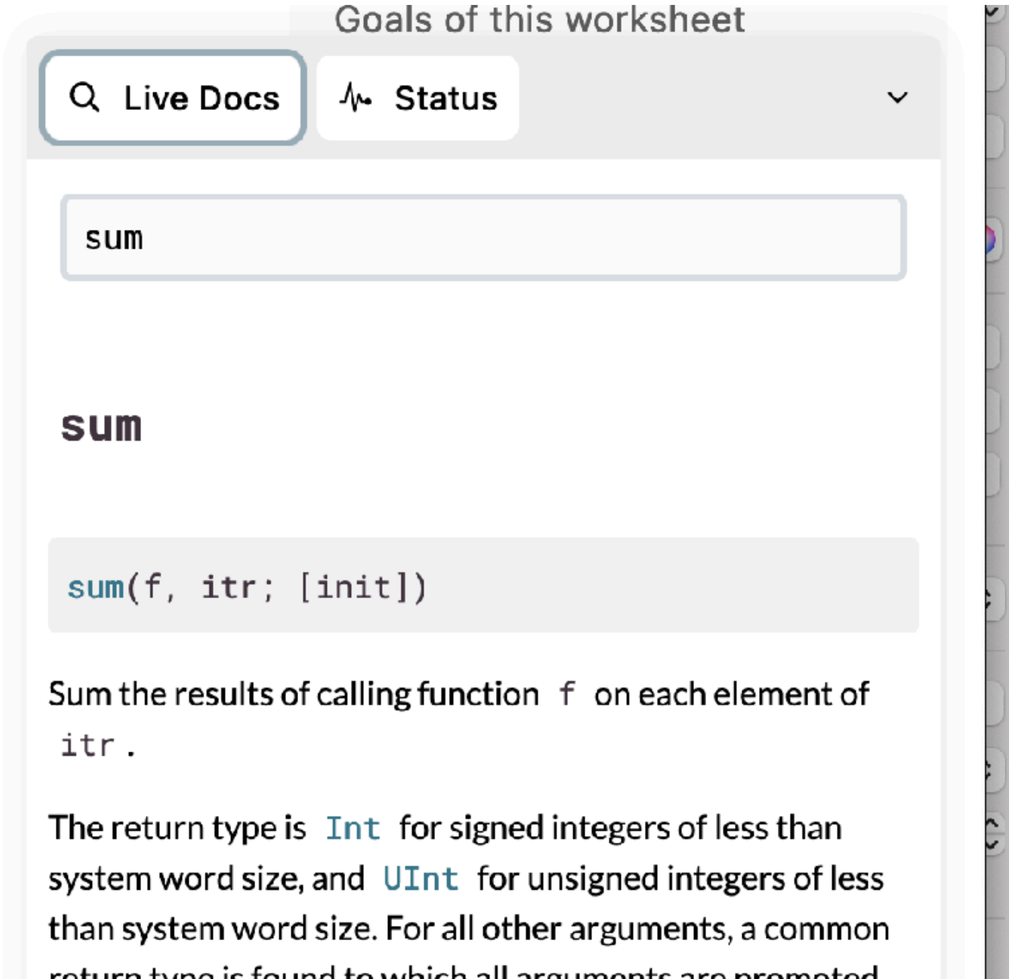
322 μs

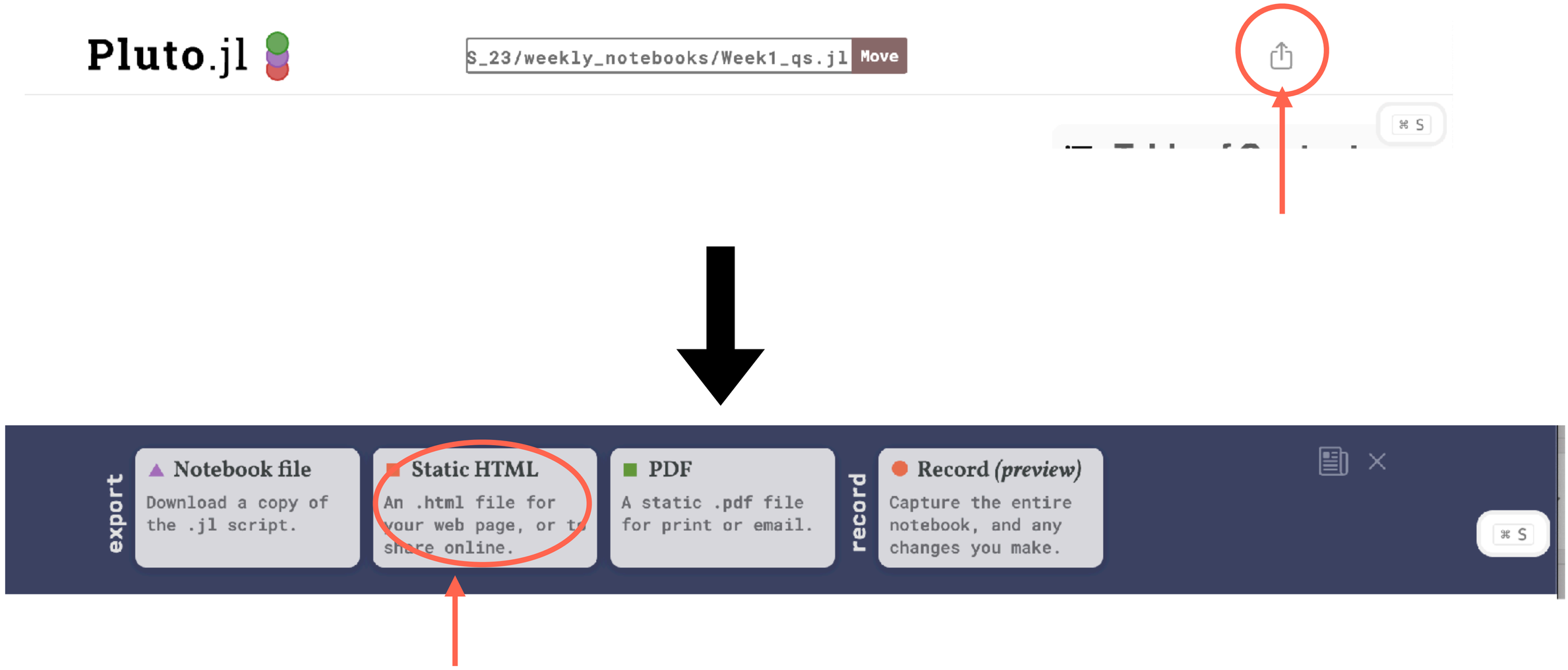
https://kapeli.com/cheat_sheets/LaTeX_Math_Symbols.docset/Contents/Resources/Documents/index

Use the live docs

```
sum()
```

67.0 µs





Best rendering.
Open in web browser (e.g. chrome)

Course etiquette

Start the notebooks early

Annotate the notebooks massively

Don’t give up!!!

Course etiquette

Use the padlet:

Attend labs
(attendance will be recorded)

Missing the labs?

Send excuses **during missed lab**

(Timed email)

Relaxed, creative, perseverance

Ironclad ego

Spend time on a question without worrying

Ask naive questions

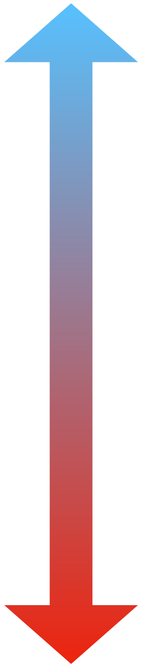
Playfulness

Maths is a game! Take breaks

Don’t get in a hole: change tactics

How to collaborate and use the answers

Using answers when completely stuck



Sharing approaches and perspectives

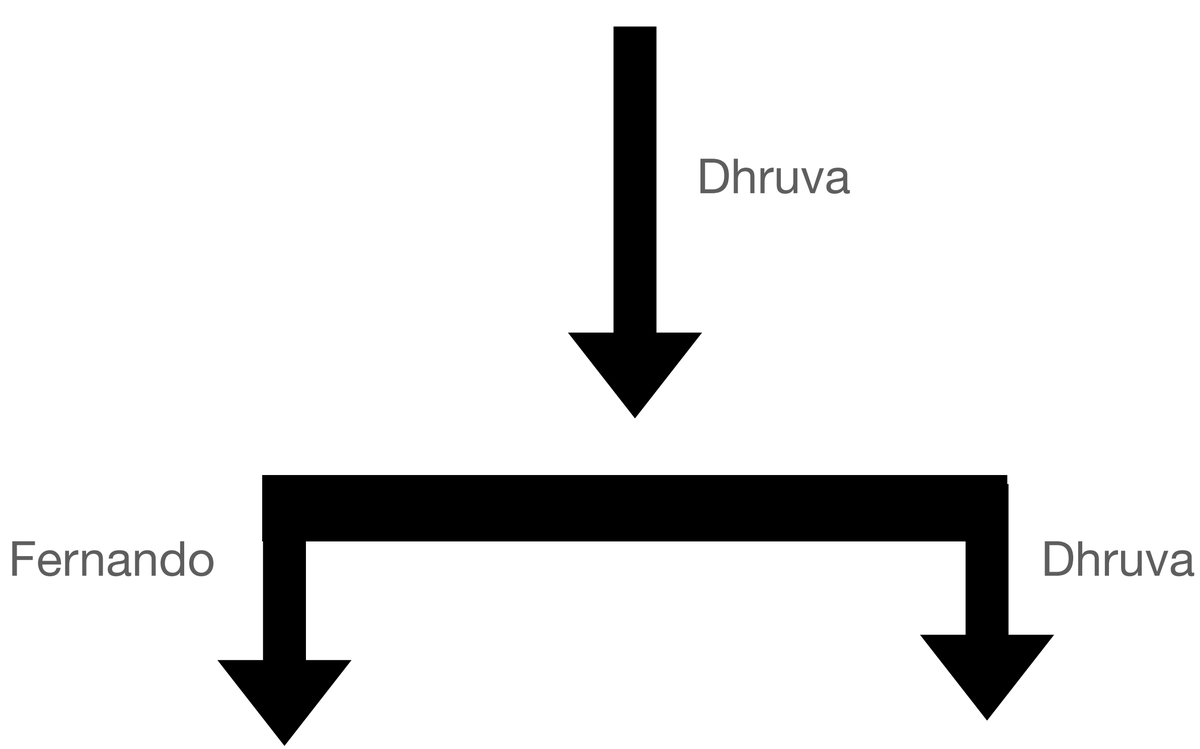
Using answers when mildly bored

Blindly copying

Doing it wrong?

The only person who gets hurt is you

Course structure



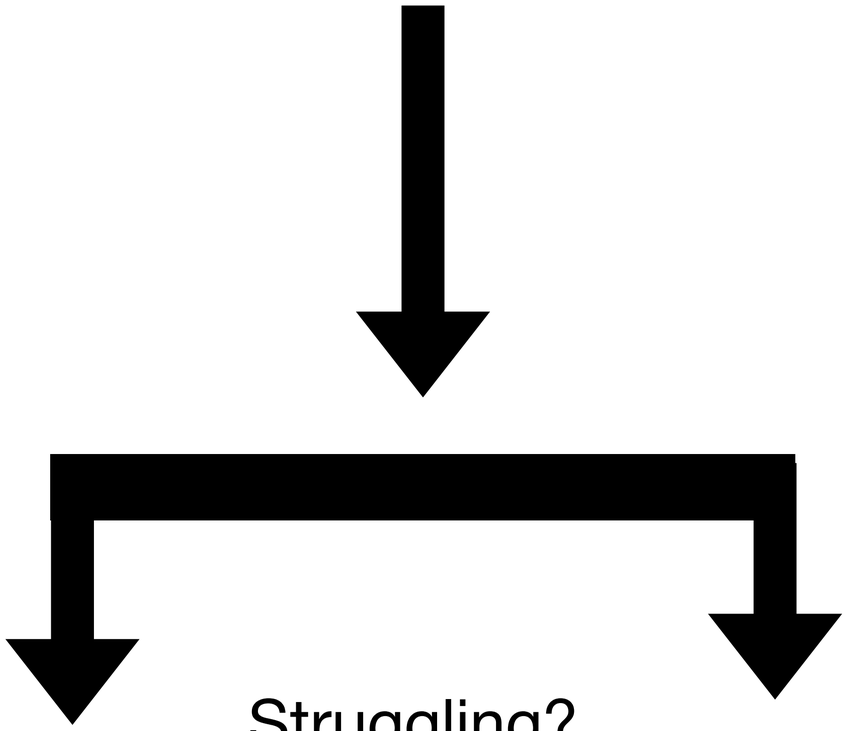
Weeks 1-6

≈ 1hr lectures

Weeks 7-10

≈ 1hr lectures × 2

Course structure

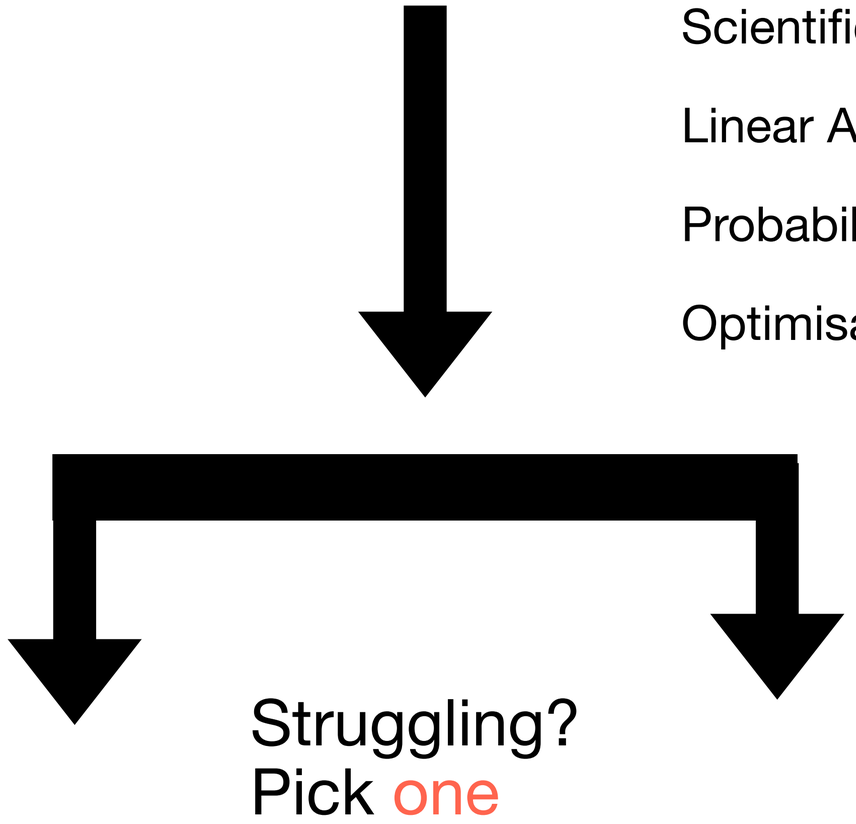


Struggling?
Pick one

Weeks 1-6
≈ *1hr lectures*

Weeks 7-10
≈ *1hr lectures* × 2

Course structure



Scientific computing

Linear Algebra

Probability

Optimisation theory

Dynamical systems

Complexity theory

Statistics

More optimisation

Struggling?
Pick one

Asking questions

During/after the lecture

During seminars

⋮

Fernando’s office hours

Monday, 1500-1700

Chichester 1: First floor
(C1-160)

Summary

You learn when you're patient
and when you have fun

Do the notebooks
conscientiously

Ask questions and
talk to colleagues

Be proactive!!

Now…

Get working on notebook 1!!!