

Programming Habits

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Good programming habits

In this course, we'll write/read programs:

```
Vstar = Iinput*R + Vrest;          %Define Vstar = target voltage.  
tau = R*C;                        %Define tau = time constant  
  
for k=1:400-1  
    V(k+1) = V(k) + dt*(-(V(k)-Vstar)/tau);      %For each time step,  
    if V(k+1) > Vth                            %...evaluate V at the next time step  
        V(k+1) = Vreset;                         %When we cross threshold  
        n_spikes = n_spikes+1;                    %...set V to reset  
    end                                            %...and add 1 to spike counter.  
end  
  
taxis = (1:length(V))*dt;           %Return the time axis too.
```

“code”

“comments”

Good programming habits

Q. What makes a program “good” ?

A.

- It works
- It’s interpretable
- It’s extensible

Write programs for people, not computers

You should think of (at least) 3 other people programing:

Person 1: Yourself, tomorrow.

Person 2: Yourself, in six months.

Person 3: Another user of your code.

Always code as if the [person] who ends up maintaining your code will be a violent psychopath who knows where you live.

— John Woods comp.lang.c++

Write programs for people, not computers

How? Comment your code, thoroughly.

- carefully commenting code will make you happier.
 - your future self
 - popular and appreciated in your research group.

```
dt=0.1;                                %Set the timestep.  
V(1)=Vrest;                            %Set the initial condition.  
  
n_spikes = 0;                           %The # of spikes detected.  
  
Vstar = Iinput*R + Vrest;              %Define Vstar = target voltage.  
tau = R*C;                             %Define tau = time constant
```

Write programs for people, not computers

How? Make comments meaningful.

Ex.

i = 10 % i equals 10 **NO!**

plot(x,y) % plot x versus y **NO!**

Ex.

i = 10 % Define the number of iterations

plot(x,y) % Plot impulse (x) vs rate (y)

Write programs for people, not computers

How? Use comments to break programs into logical blocks

Ex.

$4+3$

NO!

$4 / 10^2$

NO!

Ex.

%% Example 1: addition.

$4+3$

%% Example 2: division and powers.

$4 / 10^2$

Write programs for people, not computers

How? Make names consistent, distinctive, and meaningful.

Ex.

```
a = 10  
b = ...  
c = my_function_18v2(a,b)
```

NO!

Ex.

```
n_trials = 10  
lfp_rat = ...  
lfp_mean = compute_trial_mean(n_trials,lfp_rat)
```

Write programs for people, not computers

How? Utilize spacing to make code stylish.

Ex.

NO!

```
Iinput=3;  
R=10;  
C=0.6;  
Vrest=-70;  
Vthreshold=-60;  
Vreset=-80;
```

Ex.

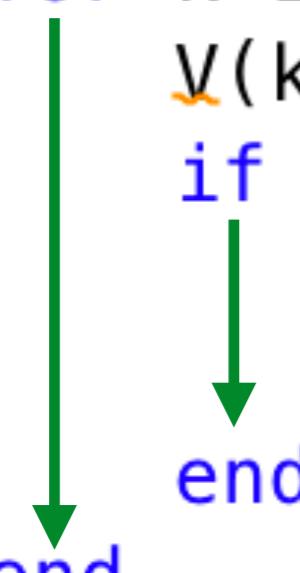
```
 Iinput      =      3;  
 R          =      10;  
 C          =      0.6;  
 Vrest      =     -70;  
 Vthreshold=    -60;  
 Vreset     =     -80;
```

Write programs for people, not computers

How? Utilize spacing to make code stylish.

Ex. `for k=1:400-1
 V(k+1) = V(k) + dt*(-(V(k)-Vstar)/tau);
 if V(k+1) > Vth
 V(k+1) = Vreset;
 n_spikes = n_spikes+1;
 end
end` NO!

Ex. `for k=1:400-1
 V(k+1) = V(k) + dt*(-(V(k)-Vstar)/tau);
 if V(k+1) > Vth
 V(k+1) = Vreset;
 n_spikes = n_spikes+1;
 end
end`



Write programs for people, not computers

How? Break up your program into manageable parts.

Ex. Books organized into chapters, paragraphs.

- Etymology
 - Extracts
1. Loomings
 2. The Carpet-Bag
 3. The Spouter-Inn
 4. The Counterpane
 5. Breakfast
 6. The Street
 7. The Chapel
 8. The Pulpit

CHAPTER 1

LOOMINGS

Call me Ishmael. Some years ago — never mind how long precisely — having little or no money in my purse, and nothing particular to interest me on shore, I thought I would sail about a little and see the watery part of the world. It is a way I have of driving off the spleen and regulating the circulation. Whenever I find myself growing grim about the mouth; whenever it is a damp, drizzling November in my soul; whenever I find myself involuntarily pausing before coffin warehouses, and bringing up the rear of every funeral I meet; and especially whenever my hypos get such an upper hand of me, that it requires a strong moral principle to prevent me from deliberately stepping into the street, and methodically knocking people's hats off — then, I account it high time to get to sea as soon as I can. This is my substitute for pistol and ball. With a philosophical flourish Cato throws himself upon his sword; I quietly take to the ship. There is nothing surprising in this. If they but knew it, almost all men in their degree, some time or other, cherish very nearly the same feelings towards the ocean with me.

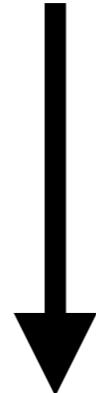
There now is your insular city of the Manhattoes, belted round by wharves as Indian isles by coral reefs — commerce surrounds it with her surf. Right and left, the streets take you waterward. Its extreme downtown is the battery, where that noble mole is washed by waves, and cooled by breezes, which a few hours previous were out of sight of land. Look at the crowds of water-gazers there.

Write programs for people, not computers

How? Break up your program into manageable parts.

Ex. Organize code into “pieces” - e.g. each piece a function.

```
d      = preprocessing(data)  
pow   = power_spectrum(d)  
coh   = coherence(d)
```



```
function output = preprocessing(d1)
```

```
    function P = power_spectrum(d1)
```

```
        function C = coherence(d1)
```

Write programs for people, not computers

How? Break up your program into manageable parts.

Ex. Organize code into “pieces” - e.g. each piece a function.

```
function output = preprocessing(data)
```

Maximum length of a function:

- ideally no more than one screen’s worth of code.

Don't repeat yourself (or others).

How? **Make the computer repeat tasks**

Ex. Cut & paste over and over again.

Challenge:

Plot $\sin(x+k\pi/4)$ where k varies from 1 to 5 in steps of 1.

Python ...

Don't repeat yourself (or others).

How? Make the computer repeat tasks

Ex. Cut & paste over and over again.

```
a = [[ some voltage trace ]];           ... some data  
t = (0:1:length(a));                   ... define axis for plot  
y = a.^2;                            ... do something to data  
plot(t,y)                           ... plot it  
title(['Plot of voltage trace A']) ... with a title.
```

```
b = [[ another voltage trace ]];        ... more data  
t = (0:1:length(b));                  ... define axis for plot  
y = b.^2;                            ... do something to data  
plot(t,y)                           ... plot it  
title(['Plot of voltage trace B']) ... with a title.
```

Don't repeat yourself (or others).

How? **Make the computer repeat tasks**

Ex. Cut & paste over and over again. Define a *function*

```
function square_and_plot(x, plot_title)
    t = (0:1:length(x));
    y = x.^2;
    plot(t,y)
    title(plot_title)
end
```

```
a = [ [ some voltage trace ] ];
b = [ [ another voltage trace ] ];
square_and_plot(a, 'Plot of voltage trace A')
square_and_plot(b, 'Plot of voltage trace B')
```

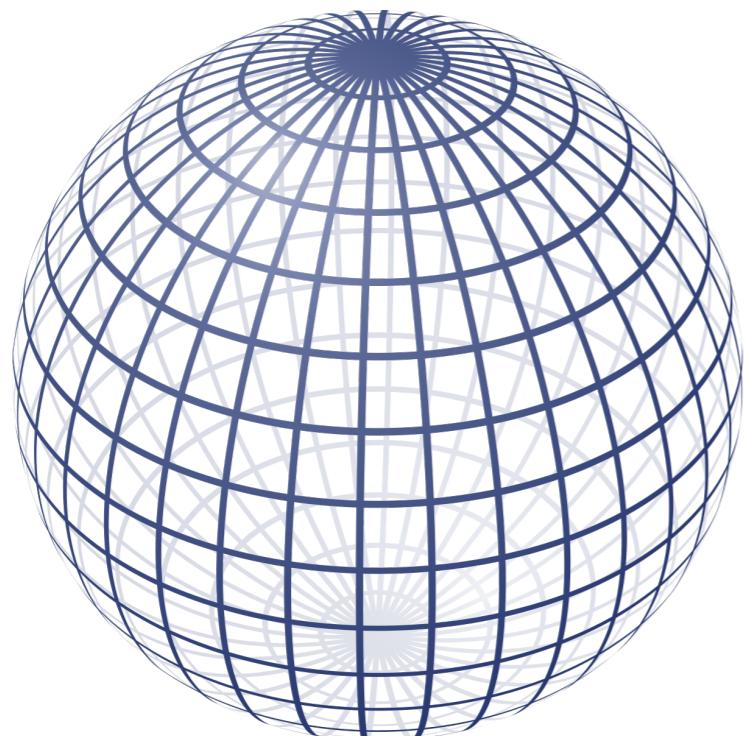
Don't repeat yourself (or others).

How?

Re-use existing functions (that you trust)

It's usually better to find an established library or package that solves a problem than to attempt to write your own routines for well established problems.

Ex. Compute the distance between two points on a sphere.



MATLAB:

```
distance(lat1,lon1,lat2,lon2)
```

Python:

```
distance = geodesic(pt1,pt2).miles
```

Visualize data

How? When in doubt, plot it out.

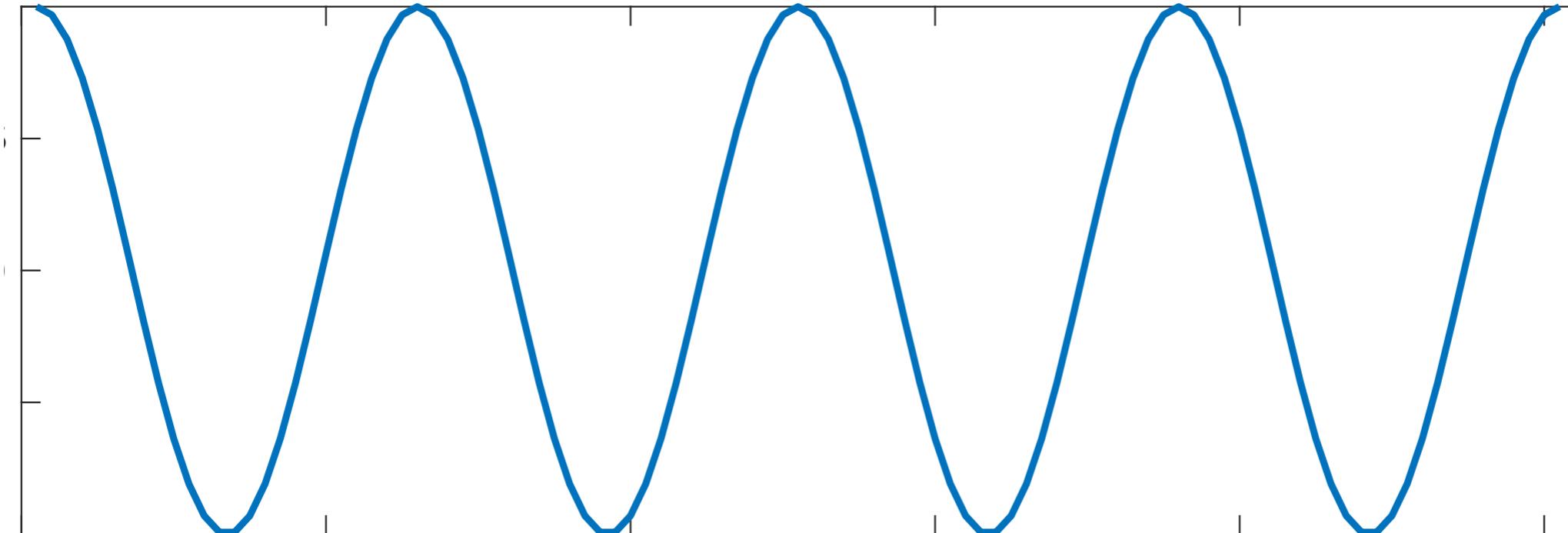
Ex. You're given the data in variable x. Let's look at it.

```
x =  
Columns 1 through 6  
    1.0000    0.9686    0.8763    0.7290    0.5358  
Columns 7 through 12  
    0.0628   -0.1874   -0.4258   -0.6374   -0.8090  
Columns 13 through 18  
   -0.9921   -0.9921   -0.9298   -0.8090   -0.6374  
Columns 19 through 24  
   -0.1874    0.0628    0.3090    0.5358    0.7290  
Columns 25 through 30  
    0.9686    1.0000    0.9686    0.8763    0.7290  
Columns 31 through 36  
    0.3090    0.0628   -0.1874   -0.4258   -0.6374  
Columns 37 through 42  
   -0.9298   -0.9921   -0.9921   -0.9298   -0.8090
```

Visualize data

How? When in doubt, plot it out.

Ex. You're given the data in variable `x`. Let's plot it.



Visualizing the data: the structure becomes clear.

Do something

Do not let these rules **stop** you from coding.

- The most important is to write code.
- Think back to these “rules” from time to time ...

Some examples from here

<https://mark-kramer.github.io/BU-NE593/Introduction.html>

Who writes programs anymore?

Built to make you extraordinarily productive,
Cursor is the best way to code with AI.

Download for macOS ↓

The screenshot shows the Cursor application window titled "PyTorch MNIST Experiments". On the left, there's a sidebar with sections "IN PROGRESS 3" and "READY FOR REVIEW 3". In "IN PROGRESS 3", there are three items: "Enterprise Order Manageme...", "Analyze Tab vs Agent Usag...", and "Fix PR Comments Fetching I...". In "READY FOR REVIEW 3", there are three items: "PyTorch MNIST Experi..." (status: now +162 -37), "Set up Cursor Rules fo...", and "Bioinformatics Tools" (status: 45m +135 -21). The main area displays a text editor with code snippets for "train_model.py", "run_experiment.py", and "config.yaml". The "train_model.py" tab is active, showing Python code for training a PyTorch model. The "run_experiment.py" tab shows a command-line runner script. The "config.yaml" tab is partially visible. A large text box in the center contains a detailed description of the experiment setup, mentioning mixed precision training, learning rate scheduling, and proper validation. It also notes the creation of an experiment config system for running different hyperparameter settings. Below this, another text box discusses updating the evaluation module to save results and generate a detailed report. At the bottom, a summary states: "Done, configurable MNIST experiment framework with AMP and reports." It lists features under "Training" (AMP, train/val split, cosine schedule, gradient clipping, checkpoints) and "Experimentation" (YAML config, saved history, confusion matrix + classification report, CLI runner).

Who writes programs anymore?

Ex.

Example 19: Defining a new function. ↗

We've spent some time in this notebook writing and executing code. Sometimes we'll need to write our own Python functions. Let's do that now.

Our function will do something very simple: it will take as input a vector and return as output the vector elements squared plus an additive constant.

If have a vector, `v`, and a constant, `b`, we would like to call:

```
vsq = my_square_function(v, b)
```

This won't work! We first need to define `my_square_function`. Let's do so now,

Using ChatGPT, using Cursor, ...

Who writes programs anymore?

Ex. Write code to print the first N digits of the Fibonacci sequence?

Example 22: Recursion (courtesy of [marieshi](#))

Let's consider a classic mathematical sequence: the [Fibonacci sequence](#). This is a sequence that starts with 0 and 1, and each number is the sum of the preceding two numbers in the sequence.

Definition [edit]

The Fibonacci numbers may be defined by the [recurrence relation](#)^[7]

$$F_0 = 0, \quad F_1 = 1,$$

and

$$F_n = F_{n-1} + F_{n-2}$$

for $n > 1$.

What you can do?

Oversee your LLM helper

- Ask the question
- Know the answer - in some sense
- Check the work

Can be a challenge

Unit test

- Small, automated test to check a single “unit” of code.
- Make sure code does what you expect.
- Simple & fast.

What you can do?

Q. What is a good unit test?

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Summary

It's (still) important to read computer code.

You will often oversee the work of an LLM.

You ask the big questions, and check the LLM's work.