M269 Overview

M269 Overview Prsntn 2025J

Phil Molyneux

5 October 2025

M269 Overview Tutorial

Agenda

- Introductions
- M269 Overview
- Basic Computational Components
- Course material and software: Jupyter Lab and Python
- Learning Software Packages
- How to Program (in two slides)
- How to survive learning software packages
- *Adobe Connect* — if you or I get cut off, wait till we reconnect (or send you an email)
- Time: about 1 hour
- Do ask questions or raise points.
- Slides/Notes M269Tutorial20241006OverviewPrsntn2024J

M269 Tutorial

Introductions — Me

- *Name* Phil Molyneux
- *Background*
  - Undergraduate: Physics and Maths (Sussex)
  - Postgraduate: Physics (Sussex), Operational Research (Brunel), Computer Science (University College, London)
  - Worked in Operational Research, Business IT, Web technologies, Functional Programming
- *First programming languages* Fortran, BASIC, Pascal
- *Favourite Software*
  - Haskell — pure functional programming language
  - Text editors TextMate, Sublime Text — previously Emacs
  - Word processing in LaTeX — all these slides and notes
  - Mac OS X
- *Learning style* — I read the manual before using the software

Introductions

Learning about IT & Software

- Medieval helpdesk with English subtitles
- For credits see Øystein and me

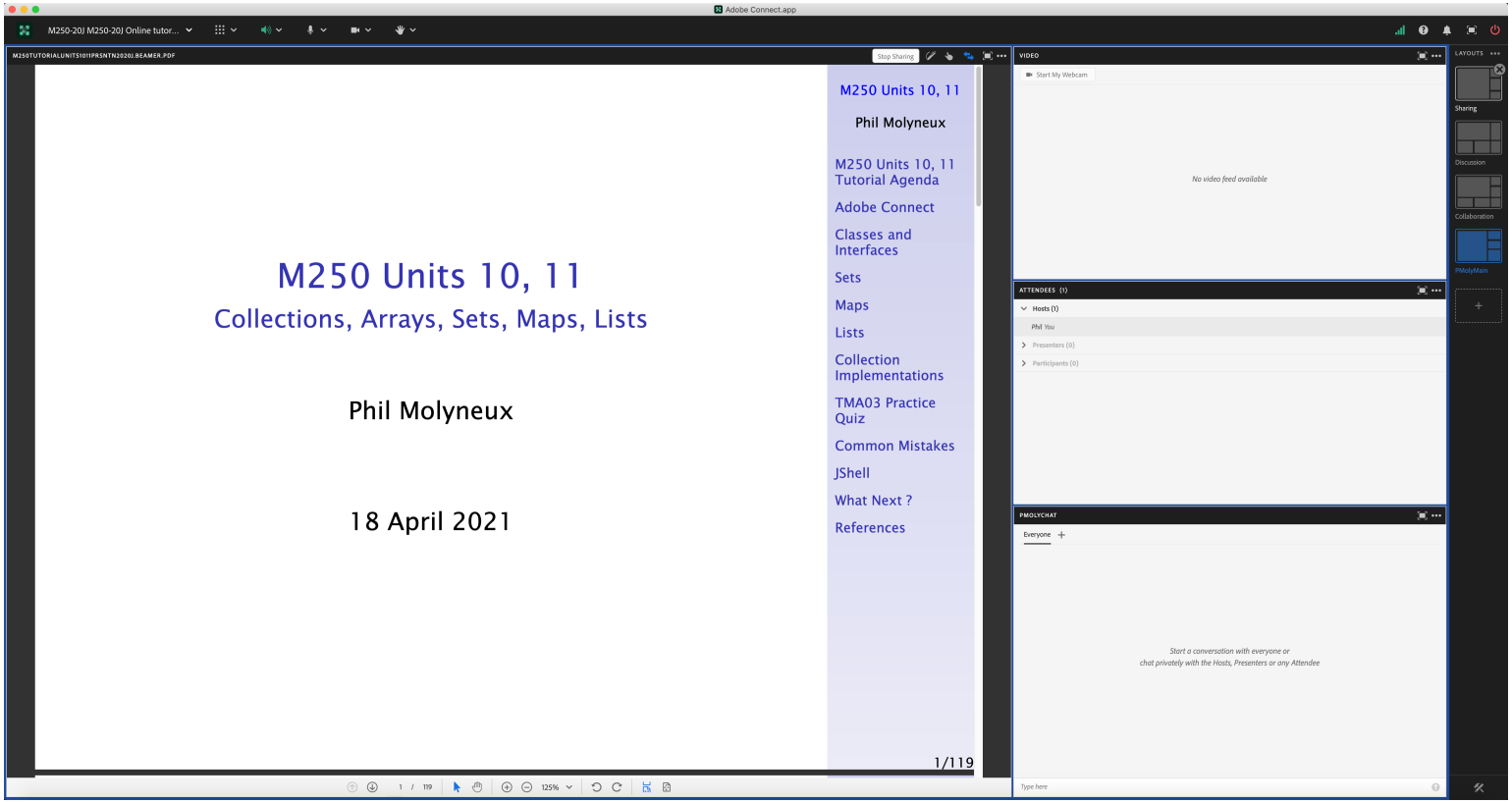
M269 Tutorial

Introductions — You

- *Name ?*
- *Favourite software/Programming language ?*
- *Favourite text editor or integrated development environment (IDE)*
- List of text editors, Comparison of text editors and Comparison of integrated development environments
- *Other OU courses ?*
- *Anything else ?*

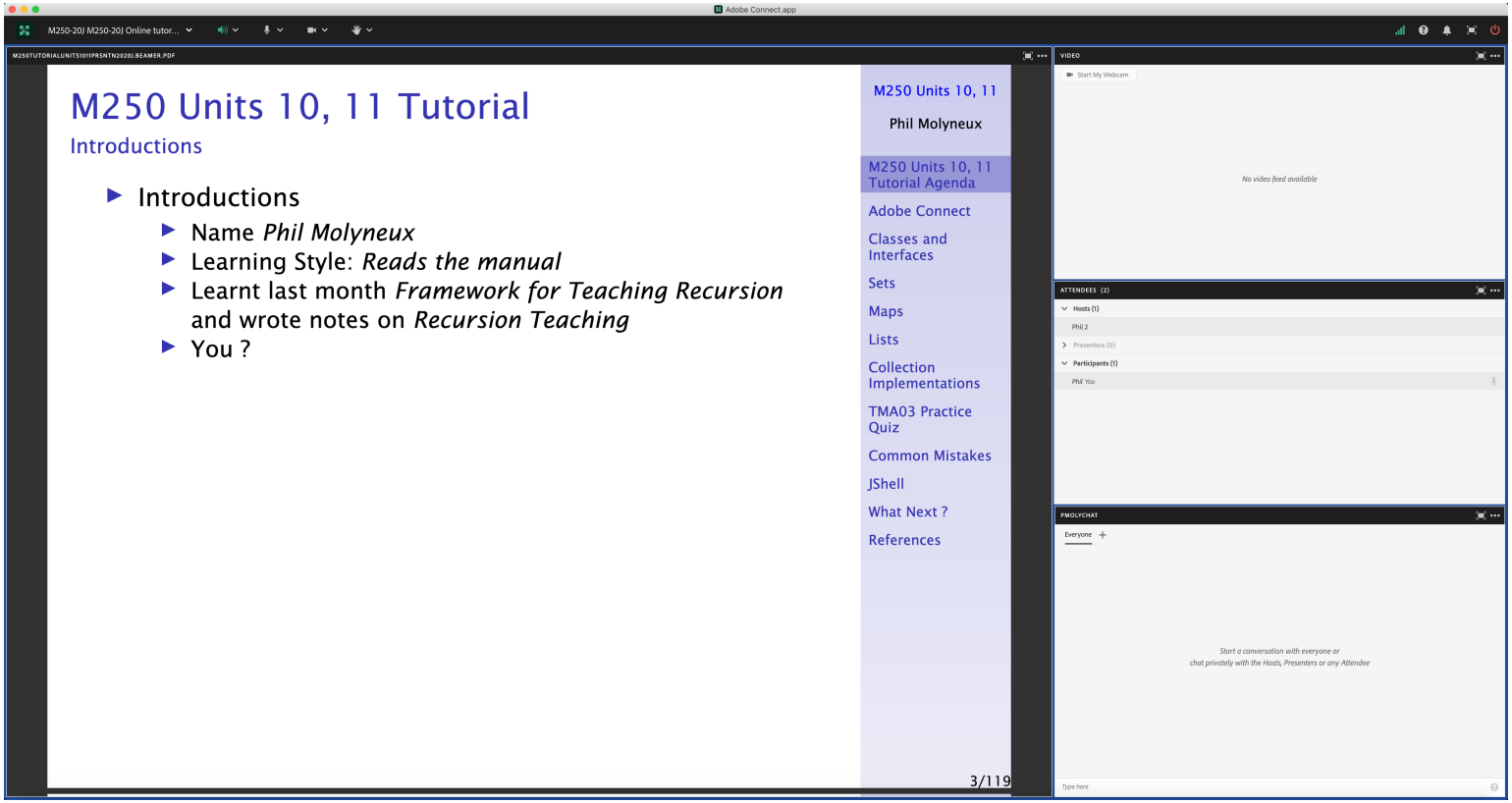
Adobe Connect

Interface — Host View



Adobe Connect

Interface — Participant View



Adobe Connect

Settings

- **Everybody** *Menu bar* › *Meeting* › Speaker & Microphone Setup
- *Menu bar* › *Microphone* › Allow Participants to Use Microphone ✔
- Check Participants see the entire slide **Workaround**
  - *Disable Draw* *Share pod* › *Menu bar* › *Draw icon*
  - *Fit Width* *Share pod* › *Bottom bar* › *Fit Width icon* ✔
- *Meeting* › Preferences › General › **Host Cursor** › Show to all attendees
- *Menu bar* › *Video* › Enable **Webcam** for Participants ✔
- Do not *Enable single speaker mode*
- Cancel hand tool
- Do not enable green pointer
- **Recording** Meeting › Record Session ✔
- **Documents** Upload PDF with drag and drop to share pod
- Delete *Meeting* › Manage Meeting Information › Uploaded Content and *check filename* › *click on delete*

Adobe Connect

Access

- **Tutor Access**

  TutorHome > M269 Website > Tutorials

  Cluster Tutorials > M269 Online tutorial room

  Tutor Groups > M269 Online tutor group room

  Module-wide Tutorials > M269 Online module-wide room

- **Attendance**

  TutorHome > Students > View your tutorial timetables

- **Beamer Slide Scaling** 440% (422 x 563 mm)

- **Clear Everyone's Status**

  Attendee Pod > Menu > Clear Everyone's Status

- **Grant Access** and send link via email

  Meeting > Manage Access & Entry > Invite Participants...

- **Presenter Only Area**

  Meeting > Enable/Disable Presenter Only Area

Adobe Connect

Keystroke Shortcuts

- Keyboard shortcuts in Adobe Connect
- **Toggle Mic** ⌘ + M (Mac), Ctrl + M (Win) (On/Disconnect)
- **Toggle Raise-Hand status** ⌘ + E
- **Close dialog box** ⎋ (Mac), Esc (Win)
- **End meeting** ⌘ + \

Adobe Connect Interface

Sharing Screen & Applications

- Share My Screen > Application tab > Terminal for Terminal
- Share menu > Change View > Zoom in for mismatch of screen size/resolution (Participants)
- (Presenter) Change to 75% and back to 100% (solves participants with smaller screen image overlap)
- Leave the application on the original display
- Beware blued hatched rectangles — from other (hidden) windows or contextual menus
- Presenter screen pointer affects viewer display — beware of moving the pointer away from the application
- First time: System Preferences > Security & Privacy > Privacy > Accessibility

Adobe Connect

Ending a Meeting

- *Notes for the tutor only*
- **Student:** Meeting > Exit Adobe Connect
- **Tutor:**
- **Recording** Meeting > Stop Recording ✔
- **Remove Participants** Meeting > End Meeting... ✔
  - Dialog box allows for message with default message:
  - *The host has ended this meeting. Thank you for attending.*
- **Recording availability** *In course Web site for joining the room, click on the eye icon in the list of recordings under your recording* — edit description and name
- **Meeting Information** Meeting > Manage Meeting Information — can access a range of information in Web page.
- **Delete File Upload** Meeting > Manage Meeting Information > Uploaded Content tab select file(s) and click Delete
- **Attendance Report** see course Web site for joining room

Adobe Connect

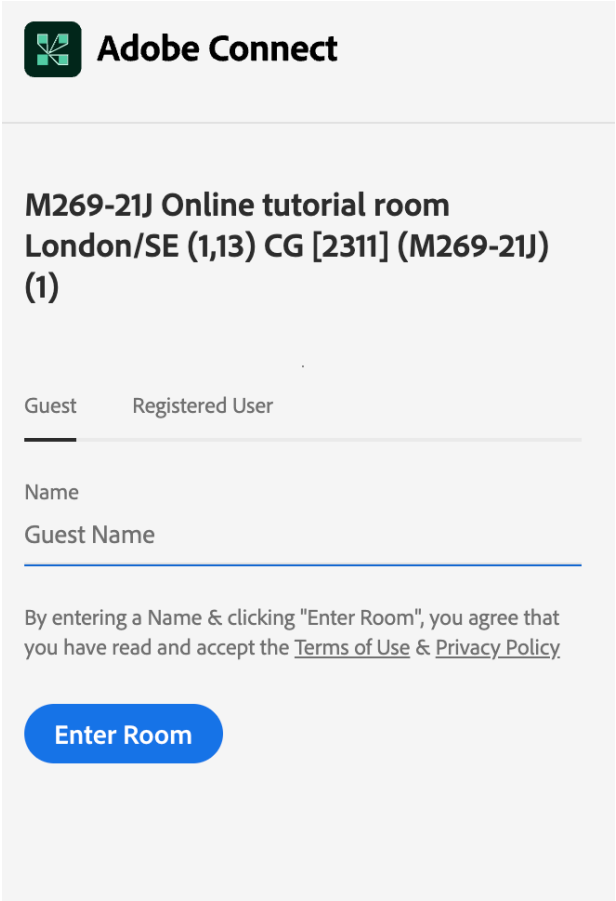
Invite Attendees

- **Provide Meeting URL** Menu > Meeting > Manage Access & Entry > Invite Participants...
- **Allow Access without Dialog** Menu > Meeting > Manage Meeting Information provides new browser window with *Meeting Information* Tab bar > Edit Information
- Check *Anyone who has the URL for the meeting can enter the room*
- Default *Only registered users and accepted guests may enter the room*
- **Reverts to default next session but URL is fixed**
- Guests have blue icon top, registered participants have yellow icon top — same icon if URL is open
- See Start, attend, and manage Adobe Connect meetings and sessions

Adobe Connect

Entering a Room as a Guest (1)

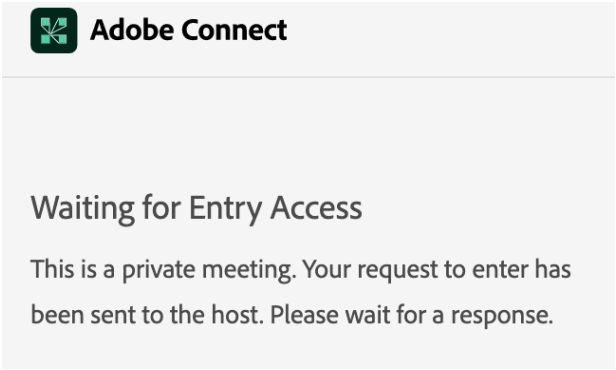
- Click on the link sent in email from the Host
- Get the following on a Web page
- As *Guest* enter your name and click on Enter Room



Adobe Connect

Entering a Room as a Guest (2)

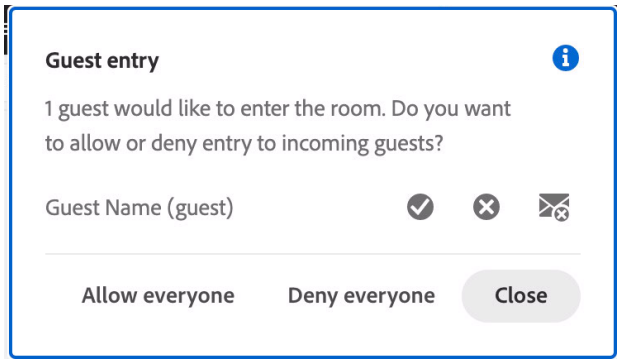
- See the *Waiting for Entry Access* for *Host* to give permission



Adobe Connect

Entering a Room as a Guest (3)

- *Host* sees the following dialog in *Adobe Connect* and grants access



Adobe Connect

Layouts

- **Creating new layouts** example *Sharing* layout
- Menu > Layouts > Create New Layout... > Create a New Layout dialog > Create a new blank layout and name it *PMolyMain*
- New layout has no Pods but does have Layouts Bar open (see Layouts menu)
- **Pods**
- Menu > Pods > Share > Add New Share and resize/position — initial name is *Share n* — rename *PMolyShare*
- **Rename Pod** Menu > Pods > Manage Pods... > Manage Pods > Select > Rename or Double-click & rename
- Add Video pod and resize/reposition
- Add Attendance pod and resize/reposition
- Add Chat pod — rename it *PMolyChat* — and resize/reposition

Adobe Connect

Layouts

- Dimensions of **Sharing** layout (on 27-inch iMac)
  - Width of Video, Attendees, Chat column 14 cm
  - Height of Video pod 9 cm
  - Height of Attendees pod 12 cm
  - Height of Chat pod 8 cm
- **Duplicating Layouts** does *not* give new instances of the Pods and is probably not a good idea (apart from local use to avoid delay in reloading Pods)
- **Auxiliary Layouts** name *PMolyAux0n*
  - Create new Share pod
  - Use existing Chat pod
  - Use same Video and Attendance pods

Adobe Connect

Chat Pods

- **Format Chat text**
- Chat Pod > menu icon > My Chat Color
- Choices: Red, Orange, Green, Brown, Purple, Pink, Blue, Black
- Note: Color reverts to Black if you switch layouts
- Chat Pod > menu icon > Show Timestamps

Graphics Conversion

PDF to PNG/JPG

- Conversion of the screen snaps for the installation of Anaconda on 1 May 2020
- Using GraphicConverter 11
- File > Convert & Modify > Conversion > Convert
- Select files to convert and destination folder
- Click on Start selected Function or ⌘ + ⏎

Adobe Connect Recordings

Exporting Recordings

- *Menu bar* > *Meeting* > Preferences > Video
- Aspect ratio > Standard (4:3) (not Wide screen (16:9) default)
- Video quality > Full HD (1080p not High default 480p)
- **Recording** *Menu bar* > *Meeting* > Record Session ✔
- **Export Recording**
- *Menu bar* > *Meeting* > Manage Meeting Information
- *New window* > Recordings > *check Tutorial* > Access Type button
- check Public > check Allow viewers to download
- **Download Recording**
- *New window* > Recordings > *check Tutorial* > Actions > Download File

M269 Algorithms, data structures and computability

Aims

- Ideas of *computational thinking*
- Introduction to algorithms and data structures (using *Python*)
- Logic and the limits of computation
- Computability
- Complexity

M269 Algorithms, data structures and computability

Topics Weeks 1–10

- Numbers and sequences — functions, complexity, data types
- Booleans and selection — Abstract Data Type (ADT), Decision problems
- Sequences and iteration — control structures for iteration, lists, tuples
- Implementing sequences — arrays as primitives, lists in arrays
- Stack and queues — example ADTs
- Unordered collections — maps, dictionaries, hash tables, sets, bags

M269 Algorithms, data structures and computability

Topics Weeks 11–20

- Exhaustive search
- Recursion — some historical context
- Divide and conquer
- Sorting
- Tree data structures
- Graph algorithms 1
- Greedy algorithms

M269 Algorithms, data structures and computability

Topics Weeks 21–30

- Graphs 2
- Backtracking
- Dynamic Programming
- Complexity classes
- Computability

Computational Components

Imperative, Procedural Programming

Imperative or procedural programming has statements which can manipulate global memory, have explicit control flow and can be organised into procedures (or functions)

- **Sequence** of statements

```
stmnt ; stmnt
```

- **Iteration** to repeat statements

```
while expr :
  suite

for targetList in exprList :
  suite
```

- **Selection** choosing between statements

```
if expr : suite
elif expr : suite
else : suite
```

Imperative, Procedural Programming

Structured Programming

- Some references on structured programming and its history in the 1960s,1970s
- Böhm and Jacopini (1966) *Flow diagrams, Turing Machines and Languages with Only Two Formation Rules*
- Structured program theorem, Structured programming
- Dijkstra (1968) *Letters to the editor: Go To Statement Considered Harmful* See Goto
- Knuth (1974) *Structured Programming with go to Statements*
- Rubin (1987) *GOTO considered harmful considered harmful* Rubin's article created a large correspondence ending in the August CACM (No. 8) with further responses by Rubin and Dijkstra
- The controversy continued with arguments about the use of `break` and `continue`

Computational Components

Functional Programming

Functional programming treats computation as the evaluation of expressions and the definition of functions (in the mathematical sense)

- **Function composition** to combine the application of two or more functions — like sequence but from right to left (notation accident of history)

```
(f . g) x = f (g x)
```

- **Recursion** — function definition defined in terms of calls to itself (with *smaller* arguments) and base case(s) which do not call itself.
- **Conditional expressions** choosing between alternatives expressions

```
if expr then expr else expr
```

Functional Programming

Recursion

- The author of these notes regards Recursion as easier than all those dreadful For loops — he may be in a minority on this one but glance at the following
- *Recursion is the GoTo of Functional Programming* was probably a term from Erik Meijer (Meijer et al (1991) *Functional programming with bananas, lenses, envelopes and barbed wire*)
- By that, Erik meant that a limited number of *Recursion Schemes* are sensible to use just as a limited number patterns of usage of *GoTo* in structured programming are captured by several syntactic constructs such as for loops and *if. . . then. . . else*
- *Structural recursion* is probably the easiest point to start using recursion but often you may get introduced through some *generative* (tricksy) recursion — see How does structural recursion differ from generative recursion?

Computation

Programming, Programming Languages

- M269 is not a programming course but . . .
- The course uses Python to illustrate various algorithms and data structures
- The final unit addresses the question:
- *What is an algorithm* ? What is programming ? What is a programming language ?
- So it *is* a programming course (sort of)

Computation

Syntax and Semantics

- **Syntax and Semantics (1)**
- What is each of the following — *first reaction !*

Computation

Syntax and Semantics

- **Syntax and Semantics (1)**
- What is each of the following — *first reaction !*
- 4 + 6

Computation

Syntax and Semantics

- **Syntax and Semantics (1)**
- What is each of the following — *first reaction !*
- $4 + 6$
- $4 + 6 \times 3$

Computation

Syntax and Semantics

- **Syntax and Semantics (1)**
- What is each of the following — *first reaction !*
- $4 + 6$
- $4 + 6 \times 3$
- 4

Computation

Syntax and Semantics

- **Syntax and Semantics (1)**
- What is each of the following — *first reaction !*
- $4 + 6$
- $4 + 6 \times 3$
- 4
- $19\,370\,721 \times 761\,838\,257\,287$

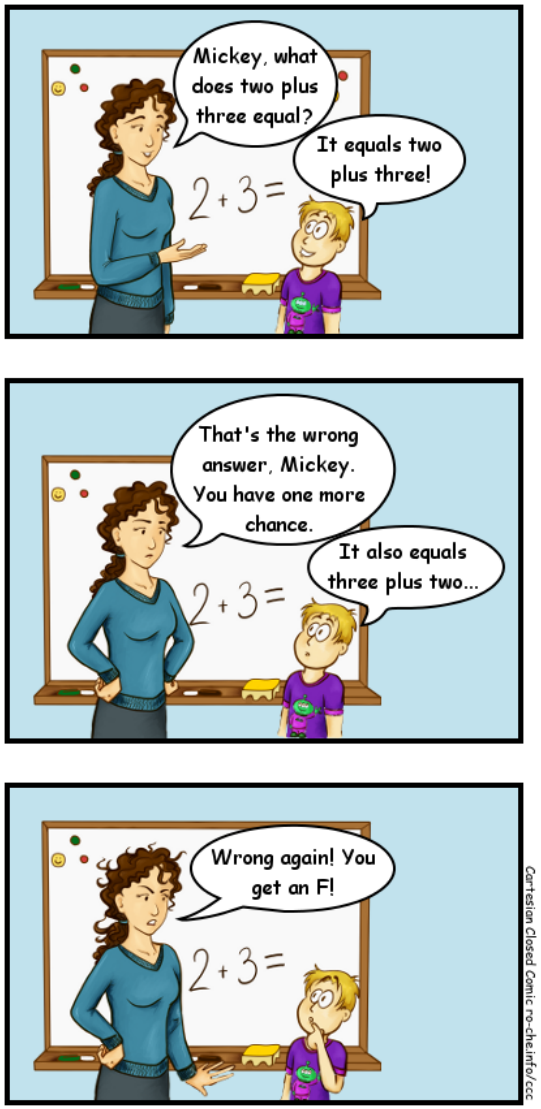
Computation

Syntax and Semantics

- **Syntax and Semantics (1)**
- What is each of the following — *first reaction !*
- $4 + 6$
- $4 + 6 \times 3$
- 4
- $19\,370\,721 \times 761\,838\,257\,287$
- The above are *expressions in arithmetic*
  - Most students read *what is* as *evaluate*
  - Not easy for the last one
  - *But* you can say:
  - *They are expressions which when evaluated, evaluate to some number*
  - $19{,}370{,}721 \times 761{,}838{,}257{,}287$
  - $= 147{,}573{,}952{,}589{,}676{,}412{,}927 = 2^{67} - 1$
  - demonstrated in a famous meeting of the New York AMS in October 1903 by F.N.Cole (Cole, 1903)

Computation

Cartesian Closed Comic — Equality



Sad fact: many math teachers do not know the difference between equality and reduction.

Computation

Syntax and Semantics

- **Syntax and Semantics (2)**
- **Evaluate**
- $6 + 4 \times 3$
- $6 - 4 - 1$
- False or True (in Python)
- 5 // 3 (integer division in Python)
- 1 // 0 (in Python)
- False or True or 1 // 0 (in Python)

Computation

Syntax and Semantics

- **Syntax and Semantics (2a)**

```
Python3>>> 6 + 4 * 3
18  # Why not 30 ?
Python3>>> 6 - 4 - 1
1   # Why not 3 ?
Python3>>> False or True
True
Python3>>> 5 // 3
1
Python3>>> 1 // 0
Traceback (most recent call last):
  File <stdin>, line 1, in <module>
ZeroDivisionError: integer division or modulo by zero
Python3>>> False or True or 1 // 0
True  # Why did it not crash as before ?
Python3>>>
```

Syntax and Semantics

Elementary Concepts

- An *expression* can be thought of as a program (and vice versa)
- A set of instructions to find a value.
- Operator *precedence* and *associativity* are there to get rid of some brackets
- (to make the code more *user friendly*!)
- **Precedence** — which operator to use first. This is also called *binding power* or operator *fixity*
- **Associativity** — for the same operator, whether to evaluate from left to right or right to left (or it doesn't matter)
- **Lazy Evaluation** — don't do today what you can put off til tomorrow, because you might never have to do it (useful in computation — not useful for doing TMAs)

Syntax and Semantics

Sharp Edges

- **Sharp edges**
- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
- In Python `2**2**2**2`
- Alternate in Python `pow(2,pow(2,pow(2,2)))`
- Microsoft Excel `=2^2^2^2`
- or use LibreOffice, Numbers, ...

Syntax and Semantics

Sharp Edges

- **Sharp edges**
- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
- $2^{2^2} = 16$ and $2^{2^{2^2}} = 2^{16} = 65536$ (or 64K in computing)

Syntax and Semantics

Sharp Edges

- **Sharp edges**
- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
- $2^{2^2} = 16$ and $2^{2^{2^2}} = 2^{16} = 65536$ (or 64K in computing)
- Python `2**2**2**2 == 65536`
- Python `pow(2,pow(2,pow(2,2))) == 65536`

Syntax and Semantics

Sharp Edges

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- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
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- Python `2**2**2**2 == 65536`
- Python `pow(2,pow(2,pow(2,2))) == 65536`
- Casio fx-85GT Plus `2^2^2^2` shows `65536`

Syntax and Semantics

Sharp Edges

- **Sharp edges**
- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
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- Casio fx-85GT Plus `2^2^2^2` shows `65536`
- Haskell `2^2^2^2 == 65536`

Syntax and Semantics

Sharp Edges

- **Sharp edges**
- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
- $2^{2^2} = 16$ and $2^{2^{2^2}} = 2^{16} = 65536$ (or 64K in computing)
- Python `2**2**2**2 == 65536`
- Python `pow(2,pow(2,pow(2,2))) == 65536`
- Casio fx-85GT Plus `2^2^2^2` shows `65536`
- Haskell `2^2^2^2 == 65536`
- Microsoft Excel `=2^2^2^2 == 256`
- *Beware language semantics*

Syntax and Semantics

Sharp Edges

- **Sharp edges**
- Evaluate (in Maths) 2^2 and 2^{2^2} and $2^{2^{2^2}}$
- $2^{2^2} = 16$ and $2^{2^{2^2}} = 2^{16} = 65536$ (or 64K in computing)
- Python `2**2**2**2 == 65536`
- Python `pow(2,pow(2,pow(2,2))) == 65536`
- Casio fx-85GT Plus `2^2^2^2` shows `65536`
- Haskell `2^2^2^2 == 65536`
- Microsoft Excel `=2^2^2^2 == 256`
- *Beware language semantics*
- Microsoft Excel `=2^2^2^2^2 == 65536`
- Haskell `length (show (2^2^2^2^2)) == 19729`
- $2^{2^{2^{2^2}}}$ has 19729 digits
- What is Excel doing differently ?

Computation

Programming Languages

- Add a tick on the slide next to languages used
- FORTRAN
- BASIC
- Pascal
- SASL
- C
- Miranda
- Prolog
- JavaScript
- Java
- Haskell
- Add names of other languages used

Computation

Programming Languages and Coding

- Are the following programming languages ?
- Excel
- HTML
- Word
- LaTeX
- SQL

Computation

Programming Languages and Coding — Excel

- **Excel**
- Excel has conditional expressions and indirections (so can have loops)
- An Excel Turing Machine is described in Felienne's blog
- Excel see Improving the world's most popular functional language: user-defined functions in Excel
- Announcing LAMBDA: Turn Excel formulas into custom functions (3 December 2020)

Computation

Programming Languages and Coding — HTML

- **HTML**
- HyperText Markup Language is the standard markup language for Web pages — it describes the structure of the content.
- It can contain CSS (for describing appearance) and
- JavaScript (for describing behaviour)
- HTML is not a programming language
- JavaScript is a Turing complete programming language but embedded in a host environment.
- CSS could be extended to be Turing complete — see Is CSS Turing complete

Computation

Programming Languages and Coding — Word

- **Word**
- Microsoft Word interface to text formatting
- Serialised with the markup language Office Open XML
- Visual Basic for Applications is embedded and is a programming language

Computation

Programming Languages and Coding — LaTeX

- LaTeX
- LaTeX is a format of TeX
- Markup technology for typesetting documents — oriented towards mathematics and technical documents.
- Is also a Turing complete programming language
- Used in MST125 Essential Mathematics 2 Unit 2 *Mathematical typesetting*

Computation

Programming Languages and Coding — SQL

- **SQL**
- Structured Query Language based on relational algebra and tuple relational calculus
- Syntactic sugar for first order logic
- Originally not a Turing complete programming language
- but extensions are Turing complete

Computation

Programming Languages and Coding

- **Turing completeness** is not everything
- Data languages such as XML, HTML, JSON
- Regular languages for regular expressions in your favourite text editor (and some programming languages)
- Pushdown automata and Context-free grammars used in program compiling.
- Total Functional Programming requires all programs to be provably terminating.

Python & Jupyter Installation

M269 Software Installation

- Chapter 1 of the M269 book directs you to **installation instructions** at dsa-ou.github.io/m269-installer/
- **macOS installation** dsa-ou.github.io/m269-installer/install-mac.html
- **Windows installation** dsa-ou.github.io/m269-installer/install-windows.html
- **macOS Jupyter Lab usage**, **Windows Jupyter Lab usage** see the links in the above
- You will need to use PowerShell (Windows) or Terminal (macOS) or a terminal (Unix/Linux)
- Note that the install will add some commands to your startup shell
- nb is created as a shortcut for `jupyter lab &` launched in a particular folder

M269 Software Installation

Commands in Initialisation Files .bashrc,.zshrc etc

```
<~><1009> alias m269-25j
m269-25j='cd␣"{Path␣to␣base␣folder}/M269-25J";
source␣~/venvs/m269-25j/bin/activate;
unalias␣allowed␣2>␣/dev/null'
```

- <~> is my Terminal prompt
- cd changes to given directory (folder)
- source execute the following shell script in the same environment
- activate sets up your Jupyter Lab and Python environment to be separate for other Python environments
- deactivate is defined in the activate script

```
<~><1010> alias nb
nb='source␣~/venvs/m269-25j/bin/activate;
unalias␣allowed␣2>␣/dev/null;
jupyter␣lab␣--custom-css␣&'
```

- This calls jupyter lab

M269 Software Installation

Commands in Initialisation Files .bashrc,.zshrc etc

- Note that there are lots of shell initialisation files
- A little knowledge of your shell commands will be useful
- For Zsh see zsh.sourceforge.io, Moving to zsh
- Bash www.gnu.org/software/bash/manual/bash.html
- Windows PowerShell Documentation
- `which python3.12` shows the difference

M269 Software Installation

TMA Notebook Setup

```
%load_ext algoesup.magics
%allowed on
%ruff on
%run -i m269_test
```

- The above are IPython Magics — see Magic functions
- See Built-in magic commands
- The M269 Book section 5.3.2 describe the ones used here
- Intended to check your coding style is in line with various style rules
- Ruff is a Python linter and code formatter written in Rust
- See PEP 8 — Style Guide for Python Code
- PEP 257 — Docstring Conventions
- PEP 20 — The Zen of Python
- PEP 484 — Type Hints

Files & Folders

Hidden Files & Folders

- Some files and folders in macOS are not displayed by default in Finder or Terminal
- These are files with names starting with a dot (.), Library folders (there are several) and some system folders
- Here are several ways of making these files visible
- **Finder (1)** with Finder selected, type ⌘ + ⇧ + . — the keystroke command is a toggle so to turn viewing off just re-type the same
- **Finder (2)** to make the change permanent, type the following in Terminal

```
defaults write com.apple.Finder AppleShowAllFiles true
killall Finder
```

- **Finder (3)** to make a permanent change without using Terminal have a look at TinkerTool (free) — the *Finder* tab first item is *Show hidden and system files*
- Also make sure you display filename extensions with Finder › Preferences › Advanced and check Show all filename extensions

Files & Folders

macOS File Paths

- Obtaining a folder or file path in Finder:
- **(1)** Drag the folder or file into a Terminal window
  the file path is displayed at the command prompt
  most often used with `cd` to change to a new folder
- **(2)** Ensure you have the *Path Bar* visible

  View > Show Path Bar

  Right-click on the folder in the Path Bar and go

  Copy *Folder* as Pathname
- **(3)** In Terminal use the `pwd` command
- **Question** What folders are represented by

  `(.)`

  `(..)`

  `./SomeFolder`

  `/SomeFolder`

  `../SomeFolder`

Python Workflows

Learning Python

- Python 3 Documentation
- Python Tutorial
- Python Language Reference
- Python Library Reference
- Stackoverflow on Python
- Lutz (2025) *Learning Python* 6th edition — see About *Learning Python, 6th Edition*
- Martelli et al (2023) *Python in a Nutshell* (fourth edition)

Basic Python

Python Usage — Questions

- How do you enter an interactive Python shell ?
- How do you exit Python in *Terminal* (Mac) or *Command prompt* (Windows) ?
- How do you get help in a shell ?
- How do you exit the *interactive help utility* ?

Basic Python

Python Usage — Answers

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Basic Python

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  Windows python3 in *Command Prompt*; *Mac python3* in *Terminal*; or *idle3* in either

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  `quit()`

- How do you get help in a shell ?

  `help()`

- How do you exit the *interactive help utility* ?

  `quit`

Basic Python

Sequences Indexing, Slices

- `xs[i:j:k]` is defined to be the sequence of items from index i to (j-1) with step k.
- If k is omitted or None, it is treated as `1`.
- If i or j are negative then they are relative to the end.
- If i is omitted or None use 0.
- If j is omitted or None use `len(xs)`
- Th *i* or *j* are omitted or None, they become end values (which end depends on *k*)

Basic Python

Python Quiz — Lists

Given the following definitions

```
xs = [10.9,25,"Phil",3.14,42,1985]
ys = [[5]] * 3
```

Evaluate

```
xs[1]
xs[0]
xs[5]
ys
xs[1:3]
xs[::2]
xs[1:-1]
xs[-3]
xs[:]
ys[0].append(4)
xs1 = xs[::-1]
```

Basic Python

Python Quiz — Lists — Answers

Given the following definitions

```
xs = [10.9,25,"Phil",3.14,42,1985]
ys = [[5]] * 3
```

Evaluate

```
xs[1]             == 25
xs[0]             == 10.9
xs[5]             == 1985
ys                == [[5],[5],[5]]
xs[1:3]           == [25, 'Phil']
xs[::2]           == [10.9, 'Phil', 42]
xs[1:-1]          == [25, 'Phil', 3.14, 42]
xs[-3]            == 3.14
xs[:]             == [10.9, 25, 'Phil', 3.14, 42, 1985]
ys[0].append(4)   == [[5, 4], [5, 4], [5, 4]]
xs[::-1]          == [1985, 42, 3.14, 'Phil', 25, 10.9]
```

Python Workflows

Command Line Python Workflow (1)

1. Create *someProgram.py* with assignment statements defining variables and other data along with function definitions.
2. There may be auxiliary files with other definitions, for example *someOtherDefinitions.py* — this uses the `import` statement in *someProgram.py*

```
from someOtherDefinitions import someIdentifier
```

3. In *someProgram.py* you can then use `someIdentifier` as a local identifier
4. To import everything

```
from someOtherDefinitions import *
```

- See Python Tutorial: Modules
- See Python Language Reference: The `import` statement

Python Workflows

Command Line Python Workflow (2)

1. Create *someDefinitions.py* with assignment statements defining variables and function definitions.
2. In *Terminal* (Mac) or *Command Prompt* (Windows), navigate to *someDefinitions.py* and invoke the *Python 3* interpreter
3. Load *someDefinitions.py* into the *Python 3* with the command

```
import someDefinitions as sdf
```

   The `as sdf` gives a shorter qualifier for the namespace — names in the file are now `sdf.x`
   Note that the commands are executed — any print statement will execute, for example
4. At the *Python 3* interpreter prompt, evaluate expressions (remember that they may have side effects and alter the current definitions)

Python Workflows

Command Line Python Workflow (3)

1. For further results, edit the file in *Your Favourite Editor* and use one of the following commands:

```
reload(sdf)

import imp
imp.reload(sdf)
```

Note the use of the name sdf as opposed to the original name.
Read the following references about the dangers of reloading as compared to re-cycling *Python 3*

- How do I unload (reload) a Python module?
- How to re import an updated package while in Python Interpreter? [duplicate]
- Reloading Python modules
- How to dynamically import and reimport a file containing definition of a global variable which may change anytime

Jupyter Notebook

Notebook File Format (1) — Optional

- Optional topic from Notebook file format
- This is not part of the course for may be of interest
- **Top-level structure**
- metadata (dict)
- nbformat (int)
- nbformat_minor (int)
- cells (list)

Jupyter Notebook

Notebook File Format (2)

- **Top-level structure**

```
{
  "metadata" : {
    "kernel_info": {
        # if kernel_info is defined, its name field is required.
        "name" : "the name of the kernel"
    },
    "language_info": {
        # if language_info is defined, its name field is required.
        "name" : "the programming language of the kernel",
        "version": "the version of the language",
        "codemirror_mode": "The name of the codemirror mode to use [optional]"
    }
  },
  "nbformat": 4,
  "nbformat_minor": 0,
  "cells" : [
      # list of cell dictionaries, see below
  ],
}
```

Jupyter Notebook

Notebook File Format (3)

- **Cell Types**
- Basic structure

```
{
  "cell_type" : "type",
  "metadata" : {},
  "source" : "single string or [list, of, strings]",
}
```

- Several basic cell types
- Markdown cells
- Code cells
- Raw NBConvert cells

Jupyter Notebook

Notebook File Format (4)

- **Markdown Cells**
- Markdown cells are used for body-text, and contain markdown, as defined in GitHub-flavored markdown, and implemented in marked.

```
{
  "cell_type" : "markdown",
  "metadata" : {},
  "source" : "[multi-line␣*markdown*]",
}
```

- It would be useful to learn some Markdown — and HTML, CSS
- **Mastering Markdown**
- **Daring Fireball: Markdown** the original reference
- **MultiMarkdown** there are lots of extensions
- Markdown Guide and references
- Python Markdown see Fenced Code Blocks

Jupyter Notebook

Notebook File Format (5)

- **Code Cells**

```
{
  "cell_type" : "code",
  "execution_count": 1, # integer or null
  "metadata" : {
      "collapsed" : True, # whether the output of the cell is collapsed
      "scrolled": False, # any of true, false or "auto"
  },
  "source" : "[some multi-line code]",
  "outputs": [{
      # list of output dicts (described below)
      "output_type": "stream",
      ...
  }],
}
```

Jupyter Notebook

Notebook File Format (6)

- **Code Cell Outputs**
- The `output_type` field defines the output
- **stream** output for text
- **display_data** data keyed by mime-type
- **execute_result** gives results of executing a cell
- **error** messages and traceback

Jupyter Notebook

Notebook File Format (7)

- **Raw NBConvert Cells**
- content that should be included unmodified in nbconvert output

```
{
  "cell_type" : "raw",
  "metadata" : {
    # the mime-type of the target nbconvert format.
    # nbconvert to formats other than this will exclude this cell.
    "format" : "mime/type"
  },
  "source" : "[some␣nbformat␣output␣text]"
}
```

Jupyter Notebook

Notebook File Format (8)

- There are a lot more features than can be covered here
- The main usage here will be adding effects to a cell
- this will require some Markdown, HTML and CSS knowledge (but not much)
- See the documentation

Learning Software Packages

Key questions

1. Where is the package source ?
2. What version are you using ?
3. What documentation is available ?
4. What are the *names* for the parts of the interface ?
5. How do you leave the package ? How do you enter the package ?
6. Is there any on-line help and, if so, how is it used ?
7. Are there any initialisation files, configuration or preferences and how are they used ?
8. How do you import and export data from the package ?
9. *When all else fails,* how can you obtain advice ?

Jupyter Lab — Exercise

Key Questions (1)

- Answer the *Key Questions* for Jupyter Lab
- Where is the package source ?
- What version are you using ?

Jupyter Lab — Exercise

Key Questions (1a)

- Where is the package source ?

  See Installing the Jupyter Software

  Python Packaging User Guide

  pip documentation

  https://jupyterlab.readthedocs.io/en/4.0.x/getting_-started/installation.html

  venv — Creation of virtual environments

  M269 Software: Installing and changing the software

Jupyter Lab — Exercise

Key Questions (1b)

- What version are you using ?

```
((m269-25j) ) <M269-25J><1013> jupyter --version
Selected Jupyter core packages...
IPython          : 8.37.0
ipykernel        : 6.29.5
ipywidgets       : 8.1.7
jupyter_client   : 7.4.9
jupyter_core     : 5.8.1
jupyter_server   : 2.16.0
jupyterlab       : 4.4.6
nbclient         : 0.10.2
nbconvert        : 7.16.6
nbformat         : 5.10.4
notebook         : 6.5.7
qtconsole        : not installed
traitlets        : 5.14.3
```

Jupyter Lab — Exercise

Key Questions (2)

- Answer the *Key Questions* for Jupyter Lab
- What documentation is available ?

Jupyter Lab — Exercise

Key Questions (2a)

- Answer the *Key Questions* for Jupyter Lab
- What documentation is available ?

  Jupyter Documentation

  Jupyter Lab Documentation

  Jupyter Notebook Documentation The Jupyter Notebook
- Jupyter Notebook Format
- The JSON Data Interchange Standard

Jupyter Lab — Exercise

Key Questions (3)

- Answer the *Key Questions* for Jupyter Notebook
- What are the *names* for the parts of the interface ?

Jupyter Lab — Exercise

Key Questions (3a)

- Answer the *Key Questions* for Jupyter Notebook
- What are the *names* for the parts of the interface ?

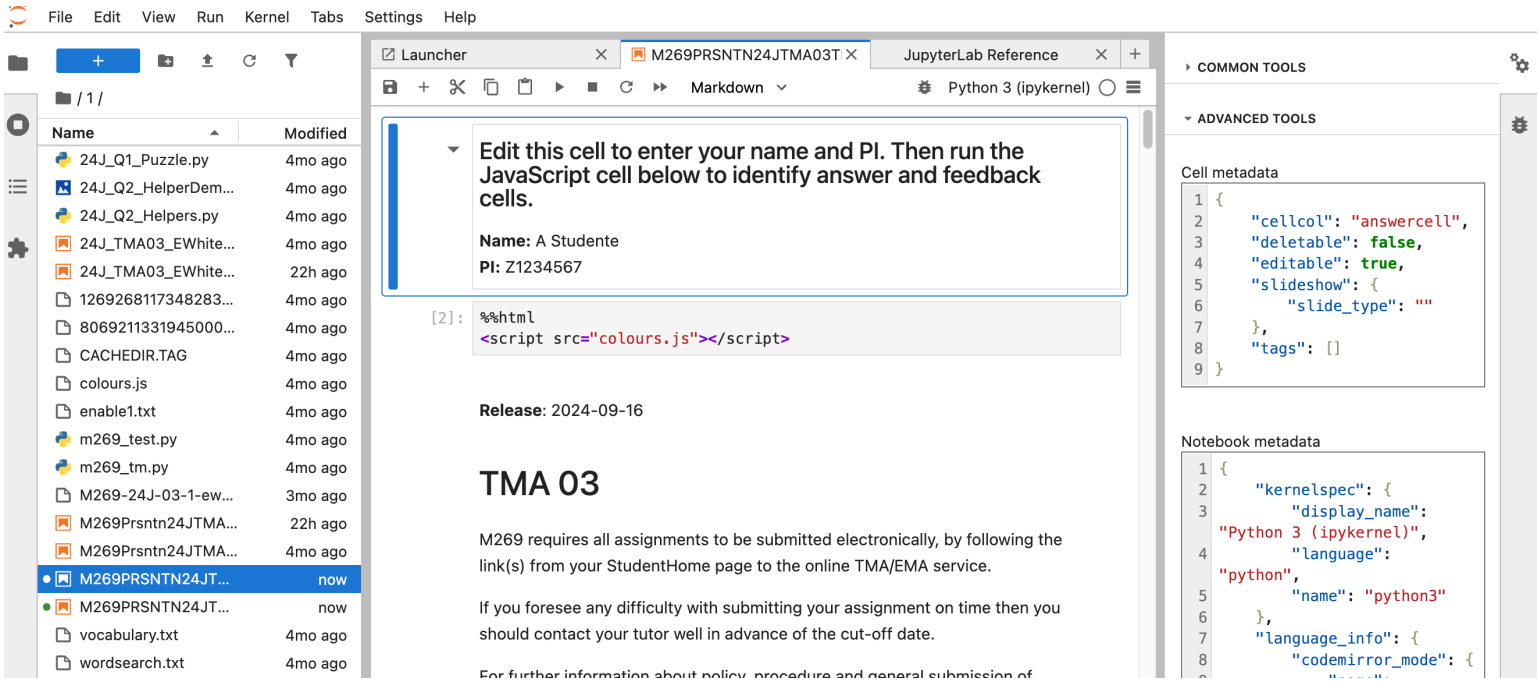
  JupyterLab Interface

  See below screen snap

  User interface components
- *Notebook Dashboard* and *Notebook Editor*
- *Command mode* and *Edit mode*

JupyterLab

JupyterLab Interface



JupyterLab Interface

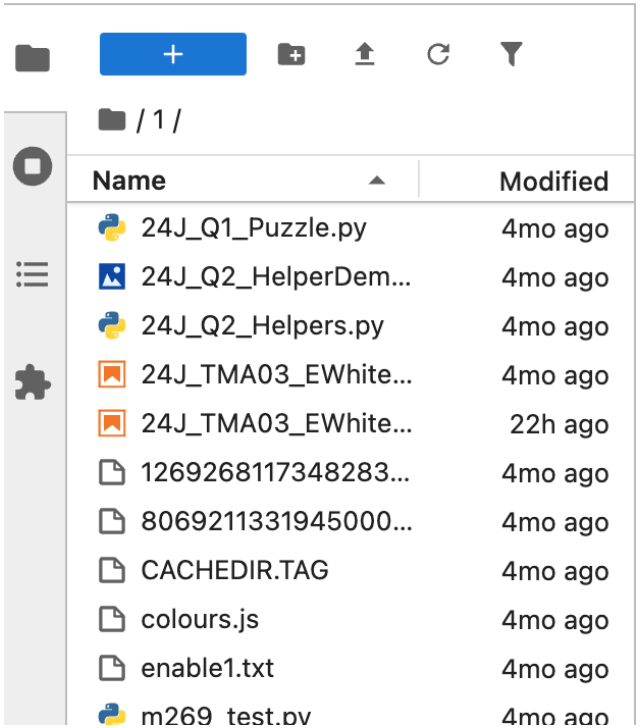
Menu Bar

- **File**: actions related to files and folders
- **Edit**: actions related to editing documents and other activities
- **View**: actions that alter the appearance of JupyterLab
- **Run**: actions for running code in different activities such as notebooks and code consoles
- **Kernel**: actions for managing kernels, which are separate processes for running code
- **Tabs**: a list of the open documents and activities in the dock panel
- **Settings**: common settings and an advanced settings editor
- **Help**: a list of JupyterLab and kernel help links

JupyterLab Interface

Left and Right Sidebar (1)

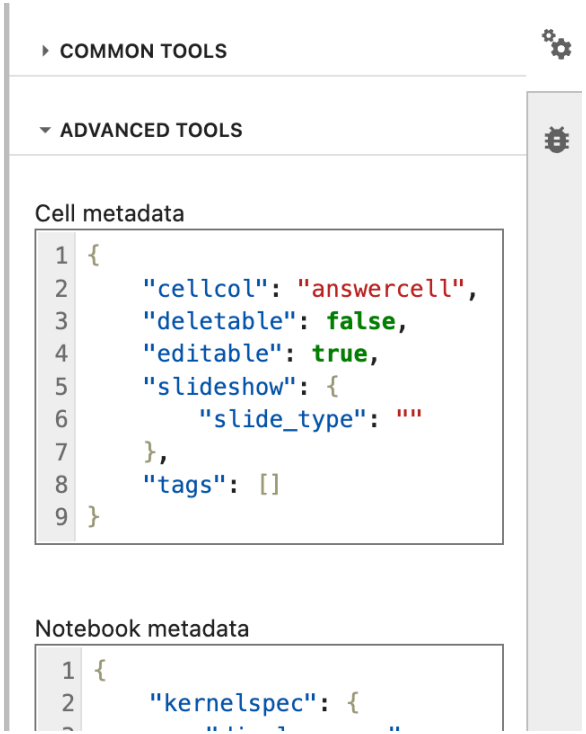
- Left sidebar: Side tabs with various roles
- File browser
- Running terminals and kernels
- Table of Contents
- Extension manager
- View > Appearance > Show Left Sidebar or ⌘ + B



JupyterLab Interface

Left and Right Sidebar (2)

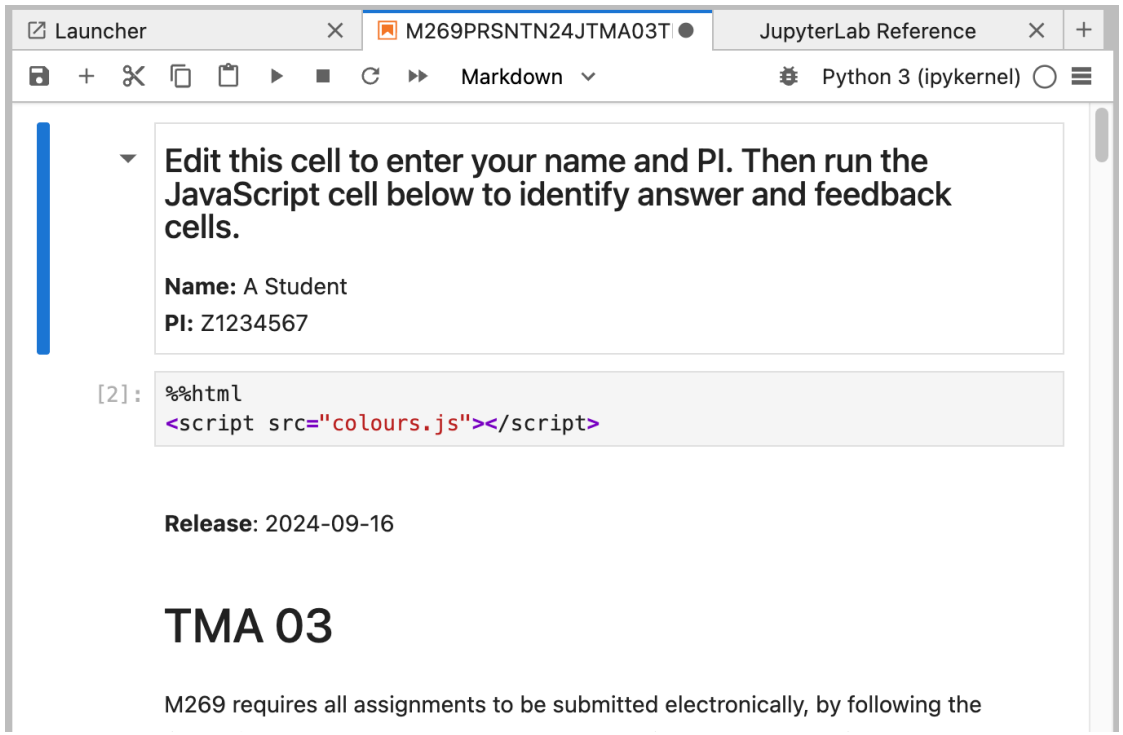
- Right sidebar: Side tabs with various roles
- Property Inspector
- Debugger
- View > Appearance > Show Right Sidebar or ⌘ + J



JupyterLab Interface

Main Work Area

- Can contain documents (notebooks, files . . .) and other activities (terminals, code consoles . . .)



Jupyter Lab — Exercise

Key Questions (4)

- Answer the *Key Questions* for Jupyter Lab &Notebook
- How do you leave the package ? How do you enter the package ?

Jupyter Lab — Exercise

Key Questions (4a)

- Answer the *Key Questions* for Jupyter Notebook
- How do you leave the package ? How do you enter the package ?
- **Enter**
- **Command line**

```
cd whatEverFolder
nb
```

- **GUI** see Windows but beware slow launch and having to navigate folders a lot
- **Leave**
- **Notebook** File > Close and Shut Down Notebook. . . ctrl + ⇧ + Q
- **Jupyter Lab** File > Shut Down
- Note File > Logout does something else and will lead to an odd request to login

Jupyter Lab — Exercise

Key Questions (5)

- Answer the *Key Questions* for Jupyter Lab
- Is there any on-line help and, if so, how is it used ?

Jupyter Lab — Exercise

Key Questions (5a)

- Answer the *Key Questions* for Jupyter Lab
- Is there any on-line help and, if so, how is it used ?

```
jupyter --help
```

but you will have to read the documentation

Jupyter Lab — Exercise

Key Questions (6)

- Answer the *Key Questions* for Jupyter Lab
- Are there any initialisation files, configuration or preferences and how are they used ?

Jupyter Lab — Exercise

Key Questions (6a)

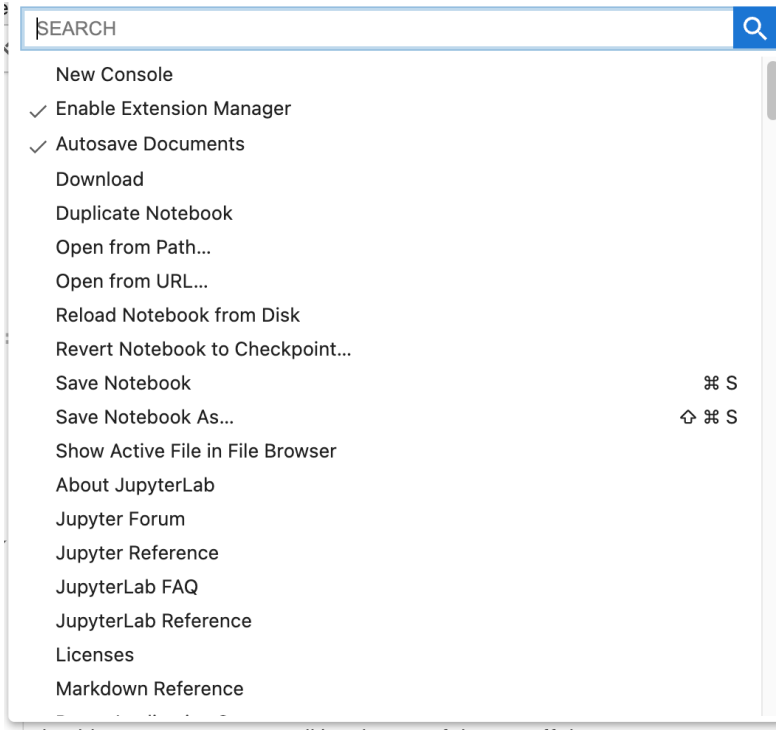
- Answer the *Key Questions* for Jupyter Lab
- Are there any initialisation files, configuration or preferences and how are they used ?
- Jupyter Lab: Advanced Usage
- See Config file and command line options
- Set in `jupyter_notebook_config.py` in `~/.jupyter` (see earlier)
- See also

```
((m269-25j) ) <M269Prsntn2024JTMAs><1010> jupyter --paths
config:
    /Users/molyneux/venvs/m269-25j/etc/jupyter
    /Users/molyneux/.jupyter
    /usr/local/etc/jupyter
    /etc/jupyter
data:
    /Users/molyneux/venvs/m269-25j/share/jupyter
    /Users/molyneux/Library/Jupyter
    /usr/local/share/jupyter
    /usr/share/jupyter
runtime:
    /Users/molyneux/Library/Jupyter/runtime
((m269-25j) ) <M269Prsntn2024JTMAs><1011>
```

JupyterLab Interface

Commands & Keystroke Shortcuts (1)

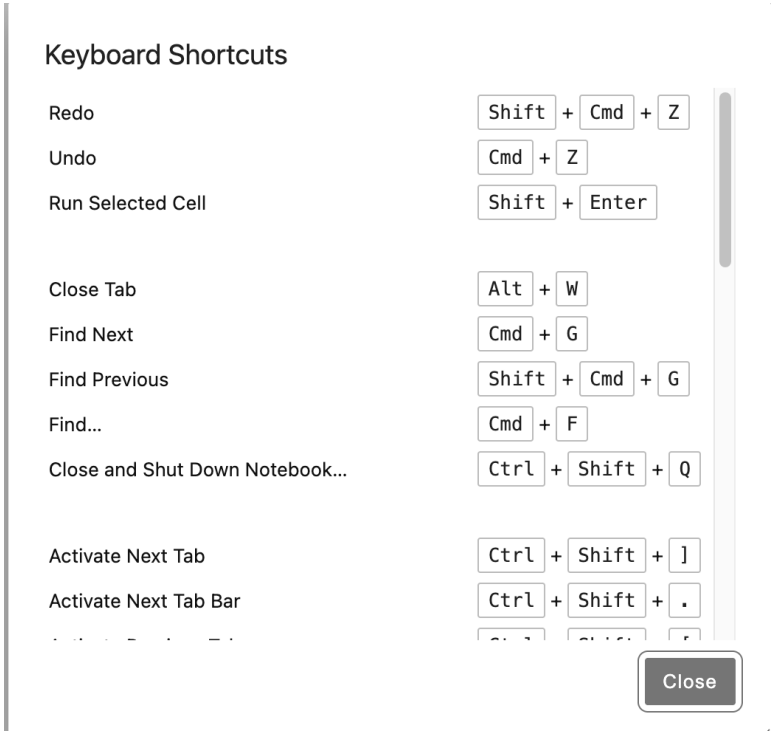
- View > Activate Command Palette or ⇧ + ⌘ + C
- Some commands have keystroke shortcuts



JupyterLab Interface

Commands & Keystroke Shortcuts (2)

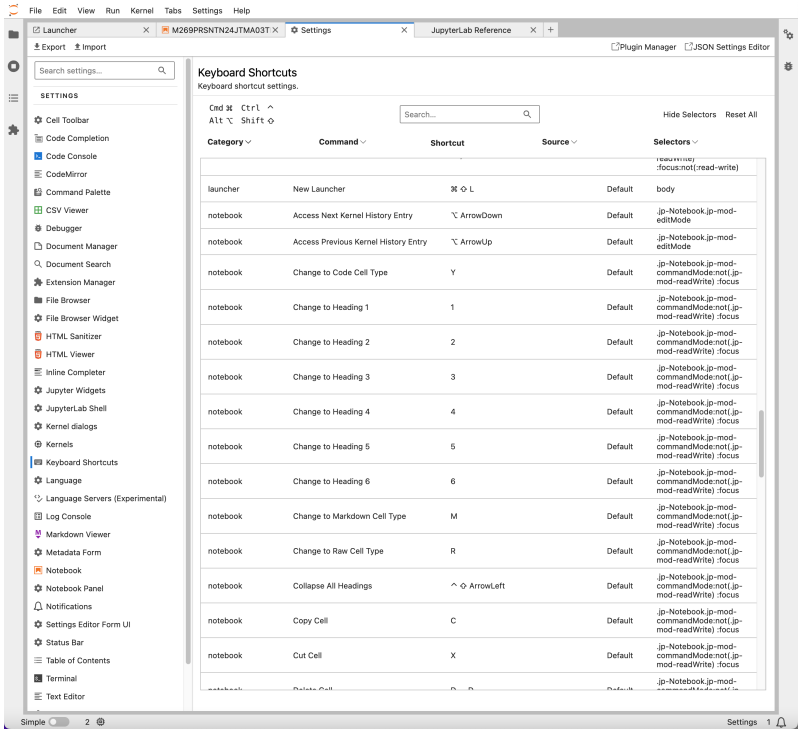
- Help > Show Keyboard Shortcuts or ⇧ + ⌘ + H



JupyterLab Interface

Commands & Keystroke Shortcuts (3)

- Settings > Settings Editor or ⌘ + ,
- Keyboard Shortcut settings below — part — there are lots



JupyterLab Interface

Commands & Keystroke Shortcuts (4)

Jupyter Notebook	Command Mode	macOS
F	Find & replace	Y Change cell to code
↵, ⏎	Enter edit mode	M Change cell to markdown
⌘ + ⇧ + F	Open command palette	R Change cell to raw
⌘ + ⇧ + P	Open command palette	1 Change cell to heading 1
P	Open command palette	2 Change cell to heading 2
⇧ + ↵, ⇧ + ⏎	Run cell, select below	3 Change cell to heading 3
^ + ⏎	Run selected cells	4 Change cell to heading 4
⌥ + ↵, ⌥ + ⏎	Run cell, insert below	5 Change cell to heading 5
⇧ + K, ⇧ + ↑	Extend selected cells above	6 Change cell to heading 6
⇧ + J, ⇧ + ↓	Extend selected cells below	K, ↑ Select cell above
⌘ + A	Select all cells	J, ↓ Select cell below
A	Insert cell above	B Insert cell below
X	Cut selected cells	C Copy selected cells
⇧ + V	Paste cells above	V Paste cells below
Z	Undo cell deletion	D , D Delete selected cells
S, ⌘ + S	Save and Checkpoint	⇧ + M Merge selected cells
L	Toggle line numbers	⇧ + L Toggle all cells line numbers
O	Toggle selected cells output	⇧ + O Toggle selected cells output scrolling
I , I	Interrupt the kernel	0 , 0 Restart the kernel (with dialog)
Esc, ⎋, Q	Close the pager	H Show keyboard shortcuts
⇧ + ␣	Scroll notebook up	␣ Scroll notebook down

Jupyter Lab — Exercise

Key Questions (7)

- Answer the *Key Questions* for Jupyter Lab
- How do you import and export data from the package ?

Jupyter Lab — Exercise

Key Questions (7a)

- Answer the *Key Questions* for Jupyter Lab
- How do you import and export data from the package ?
- **Export**
- See nbconvert — Using as a command line tool

```
jupyter nbconvert --to FORMAT myNotebook.ipynb
```

- Output formats — HTML, LaTeX, PDF, Markdown, WebPDF, Reveal.js HTML slideshow and others
- **Import**
- Embedding images — use Markdown syntax

```
    ![title][Images/myPicture.png]
```

- Convert notebook to slides

```
jupyter nbconvert --to slides --post serve myNotebook.ipynb
```

- Convert slide `myNotebook.slides.html` to PDF version — replace `#` at end of URL to `?print-pdf`

Jupyter Lab — Exercise

Key Questions (8)

- Answer the *Key Questions* for Jupyter Lab
- *When all else fails*, how can you obtain advice ?

Jupyter Lab — Exercise

Key Questions (8a)

- Answer the *Key Questions* for Jupyter Lab
- *When all else fails*, how can you obtain advice ?

  M269 Forums

  StackOverflow: Questions tagged [jupyter]

Writing Programs & Thinking

The Steps

1. Invent a *name* for the program (or function)
2. What is the *type* of the function ? What sort of *input* does it take and what sort of *output* does it produce ? In Python a type is implicit; in other languages such as Haskell a type signature can be explicit.
3. Invent *names* for the input(s) to the function (*formal parameters*) — this can involve thinking about possible *patterns* or *data structures*
4. What restrictions are there on the input — state the preconditions.
5. What must be true of the output — state the postconditions.
6. *Think* of the definition of the function body.

Writing Programs & Thinking

The *Think* Step

- **How to Think**
  1. Think of an example or two — what should the program/function do ?
  2. Break the inputs into separate cases.
  3. Deal with simple cases.
  4. Think about the result — try your examples again.
- **Thinking Strategies**
  1. Don't think too much at one go — break the problem down. Top down design, step-wise refinement.
  2. What are the inputs — describe all the cases.
  3. Investigate choices. What data structures ? What algorithms ?
  4. Use common tools — bottom up synthesis.
  5. Spot common function application patterns — generalise & then specialise.
  6. Look for good *glue* — to combine functions together.

What Next ?

Programming, Debugging, Psychology

Although programming techniques have improved immensely since the early days, the process of finding and correcting errors in programming — known graphically if inelegantly, as *debugging* — still remains a most, difficult, confused and unsatisfactory operation. The chief impact of this state of affairs is psychological. Although we are all happy to pay lip-service to the adage that to err is human, most of us like to make a small private reservation about our own performance on special occasions when we really try. It is somewhat deflating to be shown publicly and incontrovertibly by a machine that even when we do try, we in fact make just as many mistakes as other people. If your pride cannot recover from this blow, you will never make a programmer.

Christopher Strachey, Systems Analysis and Programming. Scientific American, 215(3):112–124, 1966.

What Next ?

To err is human ?

- To err is human, to really foul things up requires a computer.
- Attributed to Paul R. Ehrlich in 101 Great Programming Quotes
- Attributed to Bill Vaughn in Quote Investigator
- Derived from Alexander Pope (1711, An Essay on Criticism)
- *To Err is Humane; to Forgive, Divine*
- This also contains

  A little learning is a dangerous thing;
  Drink deep, or taste not the Pierian Spring
- In programming, this means you have to *read the fabulous manual* (RTFM)

What Next ?

Python Data Structures and Abstract Data Types

- Basic Python — selection and iteration
- Basic data types — arrays, sequences, lists, tuples
- Example Algorithm Design
- Writing Programs & Thinking — *The Steps*
- Abstract Data Types
- Tutorial online (PM) 10:00 Sunday 23 November 2025
- TMA01 Thursday 16 December 2025

Web Links & References

Historical notes

- The *offside rule* (using layout to determine the start and end of code blocks) comes originally from Landin (1966) *The next 700 programming languages* — see Wikipedia: Off-side rule for other programming languages that use this.
- The *step-by-step* approach to writing programs is described in Glaser et al (2000) *Programming by numbers: a programming method for complete novices*
- The difficulty in learning programming is described in many articles — see, for example, Dehnadi and Bornat (2006) *The camel has two humps*
- UTF-8 is Unicode (or Universal Coded Character Set) Transformation Format — 8-bit — one of the character encodings for the Unicode characters or code points

Web Links & References

Python

- Python 3.11 Documentation
- Project Jupyter Documentation
- IPython Documentation
- Martelli et al (2022) *Python in a Nutshell*
- Ramalho (2022) *Fluent Python*
- Lutz (2013) *Learning Python* — a sixth edition is due out in 2025 (see Web site in bibliography)
- Guttag (2021) *Introduction to Computation and Programming Using Python*

eb Links & References

Learning Programming & Algorithms

- **Exercism** exercism.org
- **Rosetta Code** rosettacode.org/wiki/Rosetta_Code
- **Rosetta Code Category: Programming Tasks** rosettacode.org/wiki/Category:Programming_Tasks