M269 Overview

M269 Overview Prsntn 2024J

Contents

1 M269 Overview Tutorial Agenda

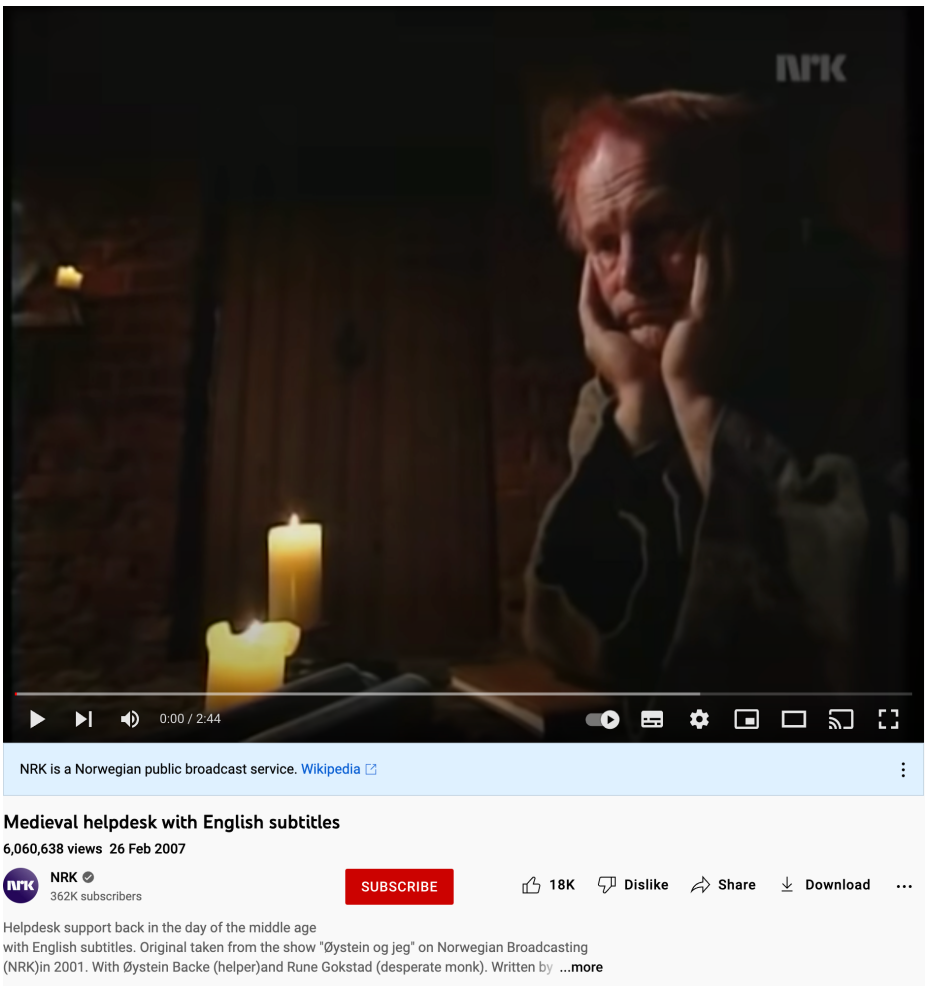
- Introductions
- M269 Overview
- Basic Computational Components

- Course material and software: Anaconda and Jupyter Notebooks
- 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

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

Medieval Helpdesk NRK 2001



- Medieval helpdesk with English subtitles

Introductions — You

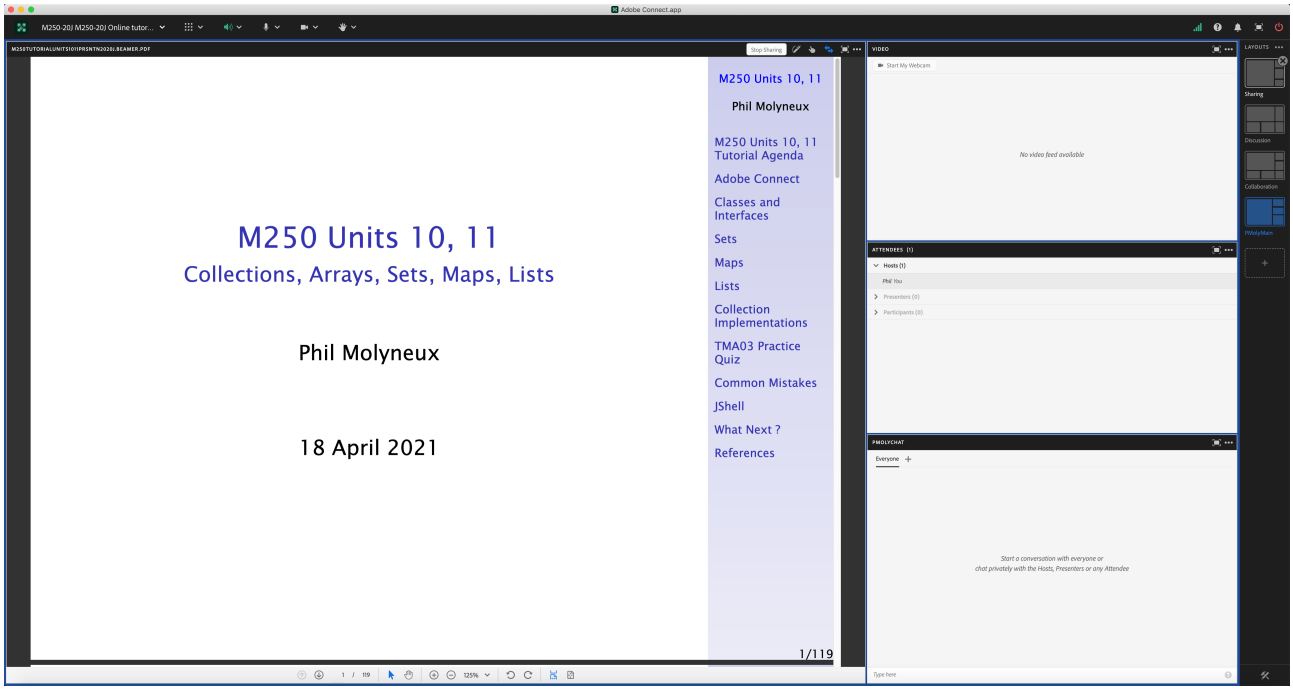
- *Name* ?
- *Favourite software/Programming language* ?
- *Favourite text editor or integrated development environment (IDE)*
- List of text editors, Comparison of text editors and Comparison of integrated development environments
- *Other OU courses* ?
- *Anything else* ?

ToC

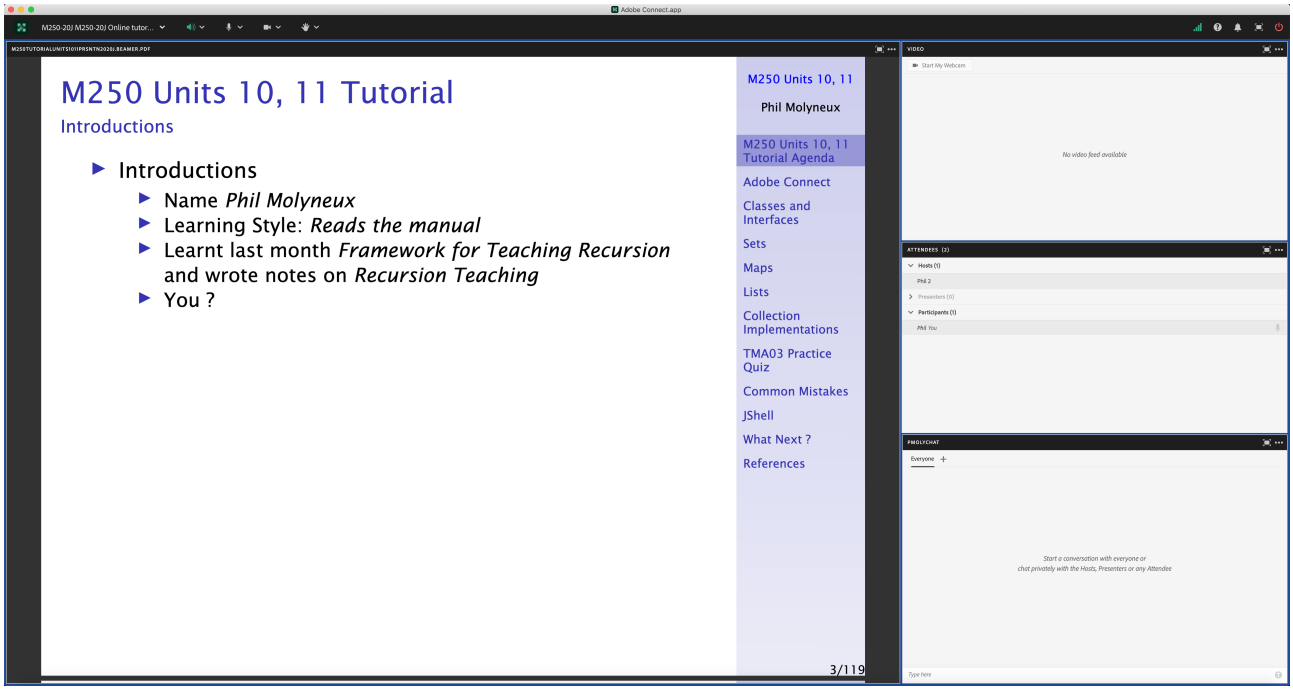
2 Adobe Connect Interface and Settings

2.1 Adobe Connect Interface

Adobe Connect Interface — Host View



Adobe Connect Interface — Participant View



2.2 Adobe Connect Settings

Adobe Connect — Settings

- **Everybody** *Menu bar* › *Meeting* › Speaker & Microphone Setup
- *Menu bar* › *Microphone* › Allow Participants to Use Microphone ✔
- Check Participants see the entire slide including slide numbers bottom right **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** ⌘ + \

2.3 Adobe Connect — 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

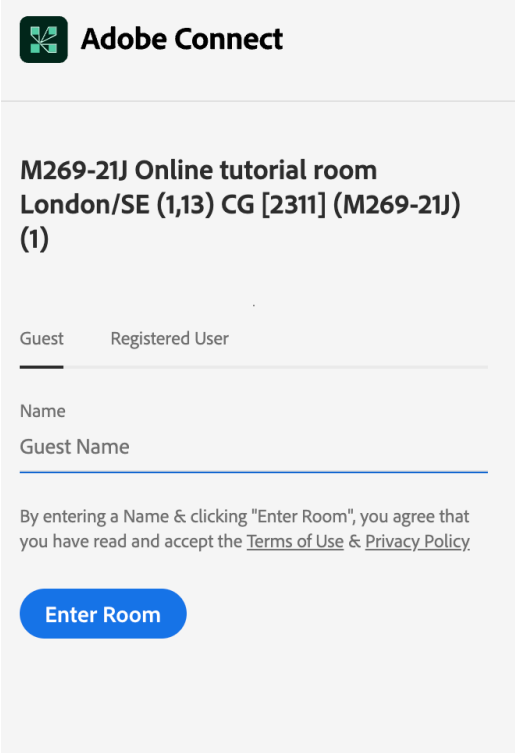
2.4 Adobe Connect — Ending a Meeting

- *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

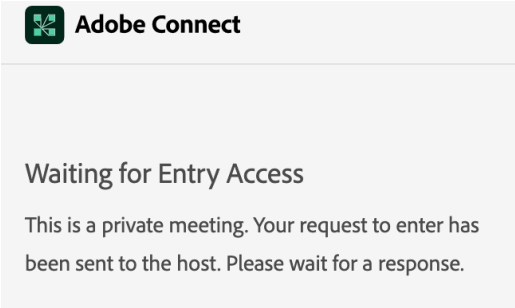
2.5 Adobe Connect — Invite Attendees

- **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
- Click on the link sent in email from the Host
- Get the following on a Web page

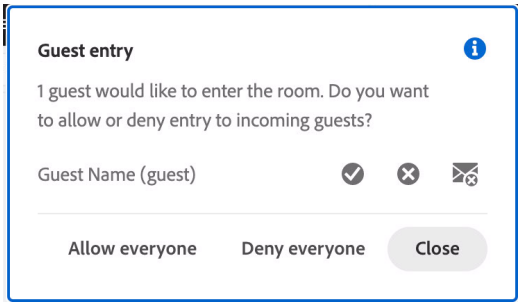
- As *Guest* enter your name and click on Enter Room



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



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



2.6 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
- 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

2.7 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

2.8 Graphics Conversion for Web

- 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 ⌘ + ⏎

2.9 Adobe Connect 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

3 M269 Overview

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

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

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

ToC

4 Basic Computational Components

Computational Components — Imperative

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
```

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
```

4.1 Computation, Programming, Programming Languages

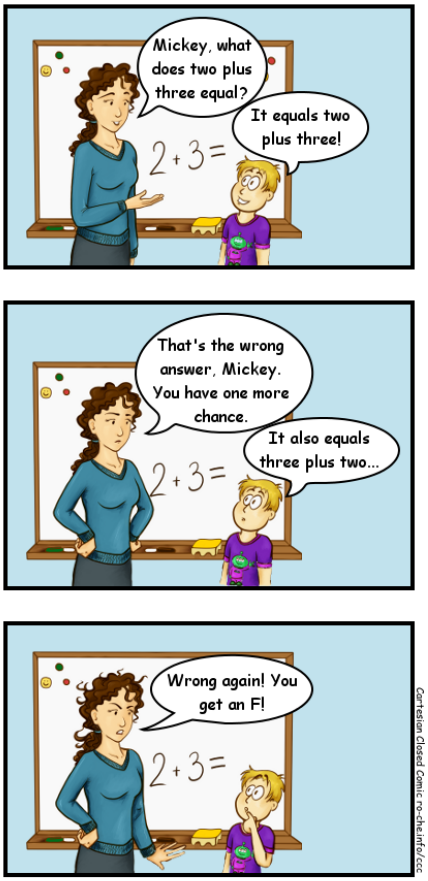
- M269 is not a programming course but . . .
- The course uses Python to illustrate various algorithms and data structures
- The final unit addresses the question:

- *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 !*
- $4 + 6$
- $4 + 6 \times 3$
- 4
- $19370721 \times 761838257287$
- 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*
  - $19370721 \times 761838257287$
  - $= 14757395258967641292 7 = 2^{67} - 1$
  - demonstrated in a famous meeting of the New York AMS in October 1903 by F.N.Cole (Cole, 1903)

Computation — Cartesian Close Comic Cartoon



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

- **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)
- **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 Sematics — 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)
- **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, . . .
- **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 ?

ToC

4.2 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
- Are the following programming languages ?
- Excel
- HTML
- Word
- LaTeX
- SQL
- **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)
- **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
- **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
- 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*
- **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
- **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.

ToC

5 Python & Jupyter Notebook

5.1 M269 Software Installation

- Chapter 1 of the M269 book directs you to installation instructions at dsa-ou.github.io/m269-installer/
- 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 notebook &` launched in a particular folder
- If you want to use Jupyter Notebook in a different folder just don't use nb — use the full command in your folder of choice

```
alias m269-24j
  ='cd␣"{Path␣to␣base␣folder}/M269Prsntn2024JSoftware/m269-24j";
␣␣source␣~/venvs/m269-24j/bin/activate;unalias␣allowed␣2>␣/dev/null'
alias nb='source␣~/venvs/m269-24j/bin/activate;
␣␣unalias␣allowed␣2>␣/dev/null;jupyter␣notebook␣&'
```

- 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
- Bash www.gnu.org/software/bash/manual/bash.html
- Windows PowerShell Documentation
- `cd` change to given directory (folder)
- `source` execute the following shell script in the same environment
- `activate` sets up your Jupyter notebook and Python environment to be separate for other Python environments
- `which python3.11` shows the difference

```
%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

ToC

5.2 Anaconda

- **Anaconda** Individual Edition
- **Anaconda documentation** Documentation
- **Anaconda documentation** Quick Start Guide
- **Anaconda Troubleshooting** Troubleshooting
- You have to pay attention to your configuration: Windows, macOS, Linux
- **macOS bash**
- The install sets up `.bash_profile` which then bypasses `.profile` and `.bashrc`
- `/Users/molyneux/opt/anaconda3/bin` is prepended to your PATH (with your user name not mine, *molyneux*)
- I have the following set in `.profile` and `.bashrc`
- **`.profile`**

```
export PYTHONSTARTUP="$HOME/.PythonStartupRC/PythonStartupRC.py"
# Sets the prompts for several Python distributions
```

- **.bashrc**

```
# Python aliases for alternate Python distributions

alias anPython="$HOME/opt/anaconda3/bin/python"
alias acPython="/usr/local/bin/python3"
alias apPython="/usr/bin/python"
```

ToC

5.3 Jupyter Notebook

- Jupyter Notebook is a Web application that allows the sharing of documents containing live code, equations and other Maths, visualisations and narrative text
- Jupyter Notebook documentation
- Launch *Jupyter Notebook*
- Navigate to the folder containing the notebooks in a command terminal (macOS Terminal)

```
jupyter notebook &
```

- Your default Web browser opens with *Notebook Dashboard*
- Navigate to a Notebook file (`*.pynb`) to launch a *Notebook Editor* on the Notebook file
- Help > User Interface Tour
- Help > Keyboard Shortcuts
- Halt a *Notebook Editor* with File > Close and Halt
- The supplied file `custom.css` (with the book files) changes some styles
- The file has to be placed at `~/.jupyter/custom/custom.css` — note the (.) in `.jupyter`
- 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
- 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`

ToC

5.4 Standalone Python Workflow

5.4.1 Learning Python

Learning Python

- Python 3 Documentation
- Python Tutorial
- Python Language Reference
- Python Library Reference
- Stackoverflow on Python
- Lutz (2013) About *Learning Python* 5th Edition
- Lutz *Learning Python* 6th edition is due in early 2025 — see About *Learning Python, 6th Edition*

ToC

5.4.2 Python Workflow

- 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* ?
- How do you enter an interactive Python shell ?

  Windows python3 in *Command Prompt*; *Mac python3* in *Terminal*; or *idle3* in either
- How do you exit Python in *Terminal* (Mac) or *Command prompt* (Windows) ?

  `quit()`
- How do you get help in a shell ?

  `help()`
- How do you exit the *interactive help utility* ?

  `quit`

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*)

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]
```

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]
```

Command Line Python Workflow

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

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)

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 recycling *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

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5.5 Notebook File Format

- 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)
- **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
  ],
}
```

- **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

- **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
- **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",
      ...
  }],
}
```

- **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
- **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]"
}
```

- 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

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6 Software & Programming

6.1 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 ?

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

  Anaconda Individual Edition

  See also Installing the Jupyter Software
- What version are you using ?

```
<~><107> jupyter --version
jupyter core     : 4.6.1
jupyter-notebook : 6.0.3
qtconsole        : 4.6.0
ipython          : 7.12.0
ipykernel        : 5.1.4
jupyter client   : 5.3.4
jupyter lab      : 1.2.6
nbconvert        : 5.6.1
ipywidgets       : 7.5.1
nbformat         : 5.0.4
traitlets        : 4.3.3
<~><108>
```

- What version are you using ? Conda information

```
<~><111> conda info
     active environment : base
    active env location : /Users/molyneux/opt/anaconda3
            shell level : 1
       user config file : /Users/molyneux/.condarc
 populated config files : /Users/molyneux/.condarc
```

```
          conda version : 4.8.2
    conda-build version : 3.18.11
         python version : 3.7.6.final.0
       virtual packages : __osx=10.14.6
       base environment : /Users/molyneux/opt/anaconda3  (writable)
           channel URLs : https://repo.anaconda.com/pkgs/main/osx-64
                          https://repo.anaconda.com/pkgs/main/noarch
                          https://repo.anaconda.com/pkgs/r/osx-64
                          https://repo.anaconda.com/pkgs/r/noarch
          package cache : /Users/molyneux/opt/anaconda3/pkgs
                          /Users/molyneux/.conda/pkgs
       envs directories : /Users/molyneux/opt/anaconda3/envs
                          /Users/molyneux/.conda/envs
               platform : osx-64
             user-agent : conda/4.8.2 requests/2.22.0 CPython/3.7.6 Darwin/18.7.0 OSX/10.14.6
                UID:GID : 501:20
             netrc file : None
           offline mode : False
<~><112>
```

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

  Jupyter Documentation

  Jupyter Notebook Documentation The Jupyter Notebook
- Anaconda Product Documentation
- Anaconda User Guide
- Conda documentation package manager
- Jupyter Notebook Format
- The JSON Data Interchange Standard
- Answer the *Key Questions* for Jupyter Notebook
- What are the *names* for the parts of the interface ?
- Answer the *Key Questions* for Jupyter Notebook
- What are the *names* for the parts of the interface ?

  User interface components
- *Notebook Dashboard* and *Notebook Editor*
- *Command mode* and *Edit mode*
- Answer the *Key Questions* for Jupyter Notebook
- How do you leave the package ? How do you enter the package ?
- Answer the *Key Questions* for Jupyter Notebook
- How do you leave the package ? How do you enter the package ?
- **Enter**
- **Command line**

```
cd whatEverFolder
jupyter notebook &
```

- **GUI** see Anaconda Navigator but beware slow launch and having to navigate folders a lot
- **Leave**
- **Notebook Editor** File > Close and Halt
- **Notebook Dashboard** Quit
- Note Logout does something else and will lead to an odd request to login
- Answer the *Key Questions* for Jupyter Notebook
- Is there any on-line help and, if so, how is it used ?
- Answer the *Key Questions* for Jupyter Notebook
- Is there any on-line help and, if so, how is it used ?

```
jupyter --help
```

but you will have to read the documentation

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

```
jupyter notebook --help
```

- Answer the *Key Questions* for Jupyter Notebook
- How do you import and export data from the package ?
- Answer the *Key Questions* for Jupyter Notebook
- 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
- Answer the *Key Questions* for Jupyter Notebook
- *When all else fails*, how can you obtain advice ?
- Answer the *Key Questions* for Jupyter Notebook
- *When all else fails*, how can you obtain advice ?

  M269 Forums

  StackOverflow: Questions tagged [jupyter]

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6.2 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.

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.

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7 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.*

- 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)

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 26 November 2023
- TMA01 Thursday 21 December 2023

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8 Web Links & References

- The *offside rule* (using layout to determine the start and end of code blocks) comes originally from Landin (1966) — 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)
- The difficulty in learning programming is described in many articles — see, for example, Dehnadi and Bornat (2006)
- 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
- 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*

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