PHAS0102: Techniques of High-Performance Computing

Who am I?

- Dr Matthew Scroggs
  - “Matthew” or “Matt”
  - matthew.scroggs.14@ucl.ac.uk
- Postdoctoral researcher in Department of Mathematics working on numerical method for PDEs.

Note

Prof Timo Betcke taught the course last year, and is still listed as lecturer in some locations.

Timo is still at UCL, so if you email him by mistake, he'll just forward it on to me.

Who are you?

Course admin

- Lectures
  - Fridays 10-11, Anatomy G04 Gavin de Beer LT
- Tutorials
  - (Group 1) Mondays 10-11, Euston Road (222) G01
  - (Group 2) Mondays 11-12, Chadwick Building 2.18
- Virtual drop-in hour
  - Wednesdays 11:30-12:30, link on Moodle

Course admin

- All this information is:
  - On Moodle
  - At https://mscroggs.co.uk/PHAS0102

Course admin: Assessment

- Coursework 1 (20%)
  - Deadline: Thursday 20 October, 5pm
- Coursework 2 (20%)
  - Deadline: Thursday 3 November, 5pm
- Coursework 3 (30%)
  - Deadline: Thursday 1 December, 5pm
- Coursework 4 (30%)
  - Deadline: Thursday 15 December, 5pm

Course admin: Assessment

- Coursework is important
    - Marking mistakes occasionally happen. If you think there’s a mistake in the marking of your coursework, email me within 1 week of getting marks back.

Course admin: Assessment

- Note: Assessments in lecture notes are **last year's assessments**. Do not start working on them!

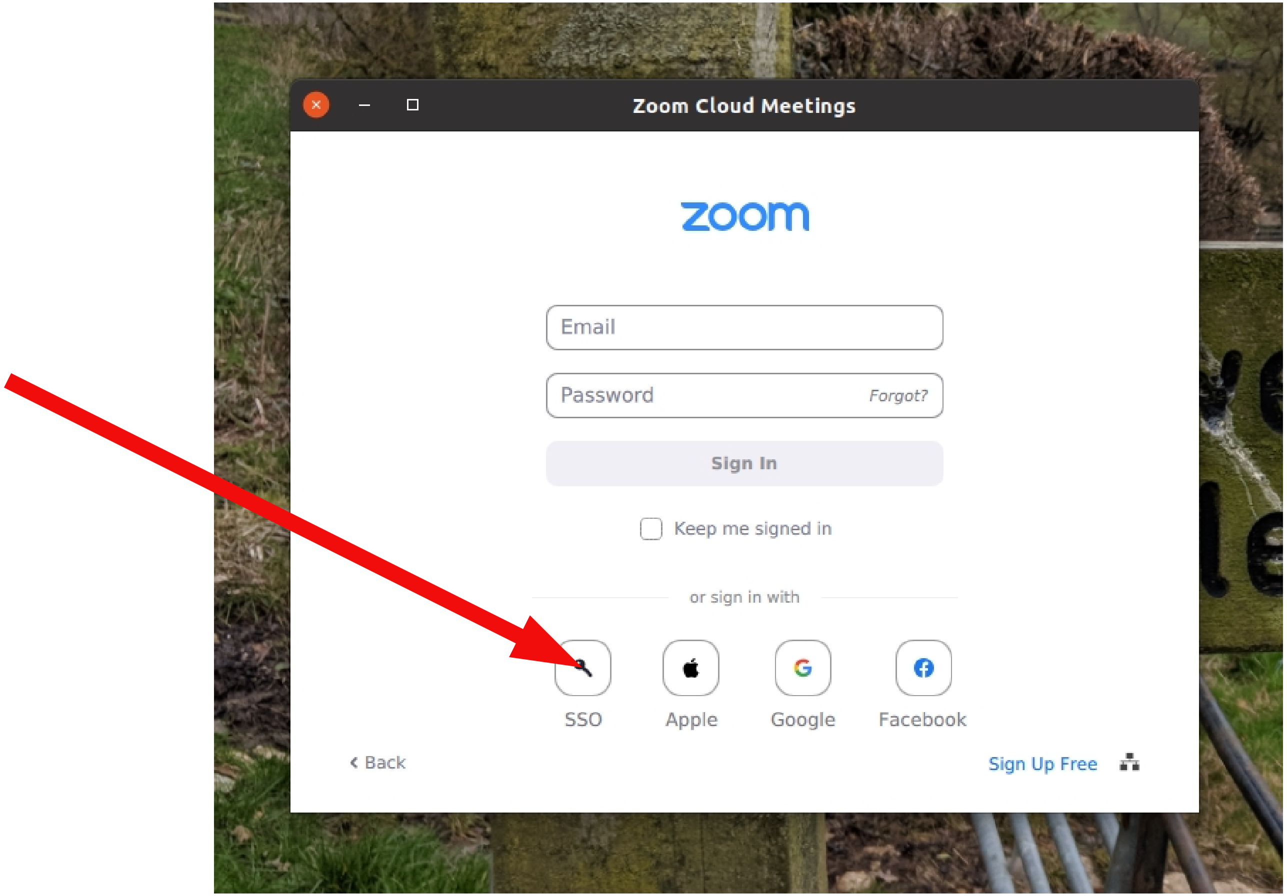
Course admin: I need help

- Lecture notes: tbetcke.github.io/hpc_lecture_notes

Course admin: I need help

- Lecture notes: tbetcke.github.io/hpc_lecture_notes
- Zoom chat: PHAS0102 (22/23)

Zoom chat


Zoom Cloud Meetings
zoom
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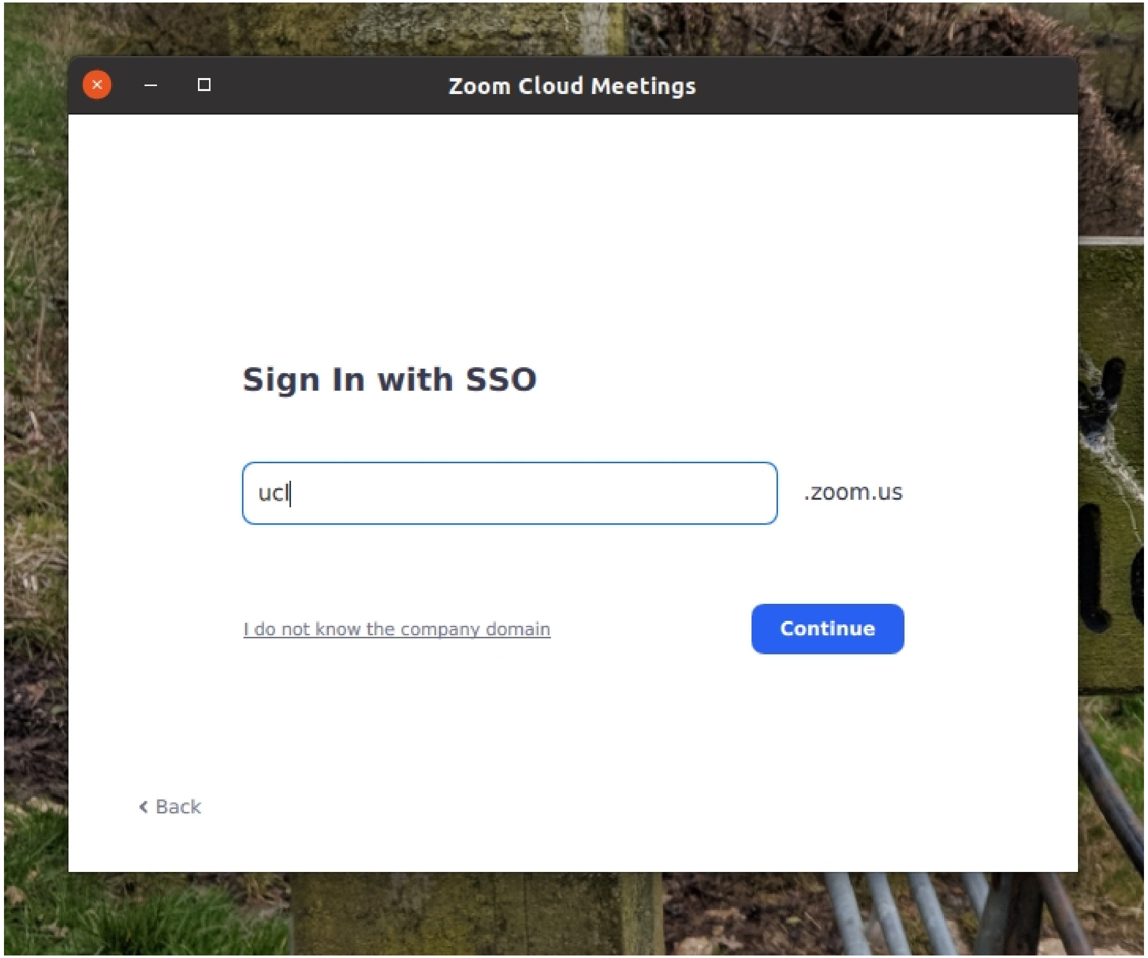
Apple
Google
Facebook
Back
Sign Up Free

Zoom chat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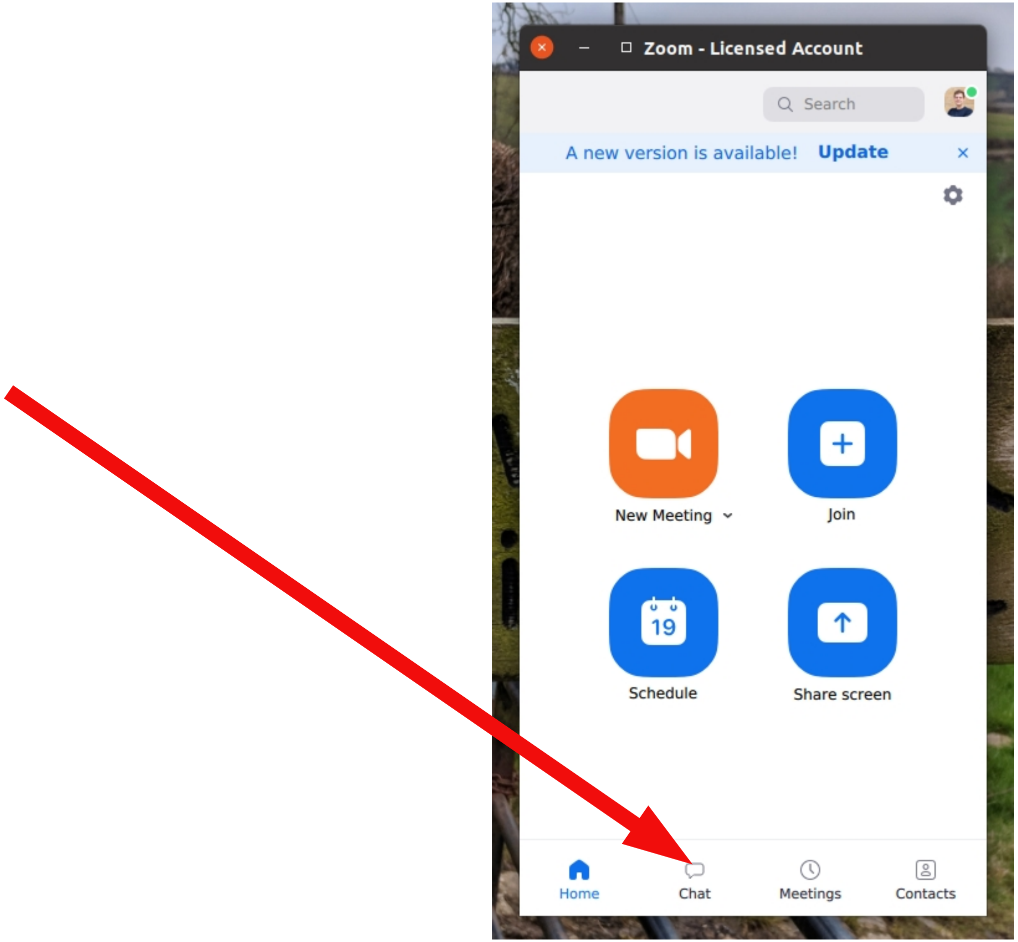
Back

Zoom chat



Search for PHAS0102 (22/23)

Course admin: I need help

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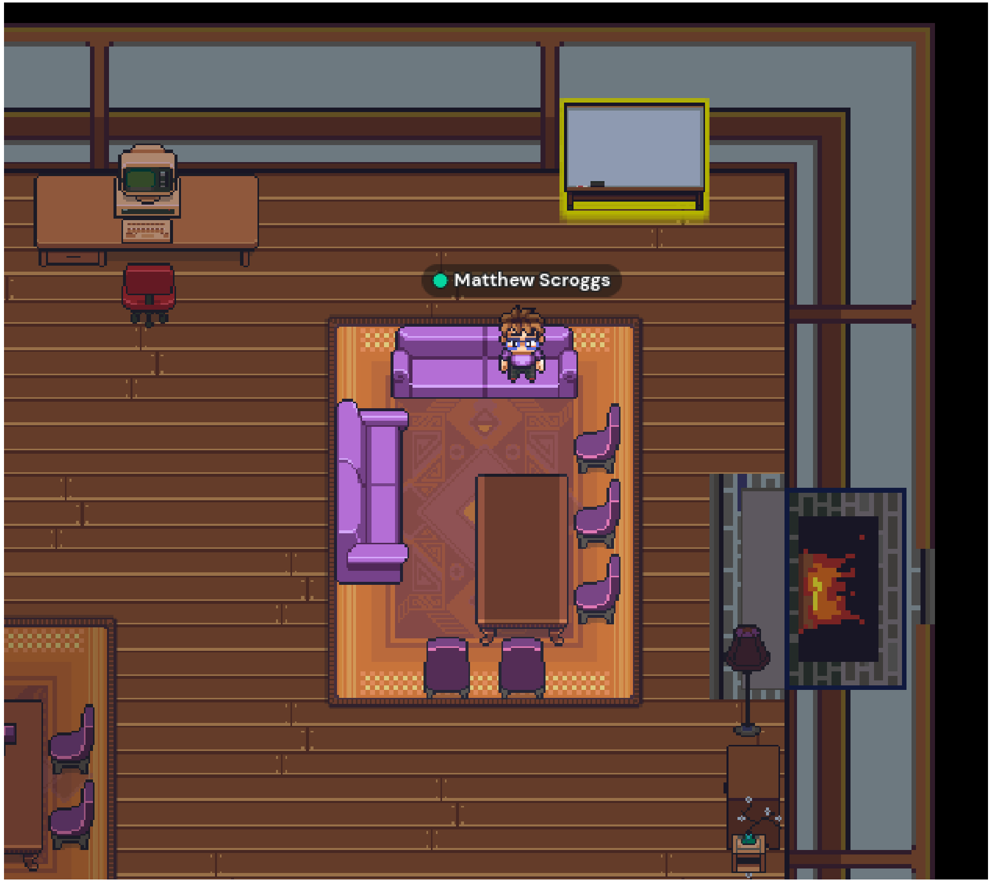
Gather Town



Course admin: I need help

- Lecture notes: tbetcke.github.io/hpc_lecture_notes
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- Email me: matthew.scroggs.14@ucl.ac.uk

Course content

- HPC with Python (~3 weeks)
- Sparse linear algebra (~5 weeks)
- Time-dependent problems (~2 weeks)

PHAS0102 Part 0:
What is High-Performance Computing?

What is HPC?

Floating point numbers

Mantissa

$$\left\{ \frac{(-1)^s b^e m}{b^{p-1}} : s \in \{0, 1\},\ e_{\min} \leqslant e \leqslant e_{\max},\ b^{p-1} \leqslant m \leqslant b^p - 1 \right\}$$

Base (2)

Exponent

Negative

Positive

Available precision

Floating point numbers

$$\left\{ \frac{(-1)^s 2^e m}{2^{p-1}} : s \in \{0,1\},\ e_{\min} \leqslant e \leqslant e_{\max},\ 2^{p-1} \leqslant m \leqslant 2^p - 1 \right\}$$

$$s = 0,\ e = 0,\ m = 2^{p-1} \quad \Longrightarrow \quad 1$$

$$s = 0,\ e = 0,\ m = 2^{p-1} + 1 \quad \Longrightarrow \quad 1 + 2^{1-p}$$

Floating point numbers

$$\left\{ \frac{(-1)^s 2^e m}{2^{p-1}} : s \in \{0,1\},\ e_{\min} \leqslant e \leqslant e_{\max},\ 2^{p-1} \leqslant m \leqslant 2^p - 1 \right\}$$

$$1,\ 1+2^{1-p},\ 1+2\times 2^{1-p},\ 1+3\times 2^{1-p},\ \ldots,\ 2-2^{1-p},\ 2$$

Floating point numbers

$$\left\{ \frac{(-1)^s 2^e m}{2^{p-1}} : s \in \{0,1\},\ e_{\min} \leqslant e \leqslant e_{\max},\ 2^{p-1} \leqslant m \leqslant 2^p - 1 \right\}$$

$$1,\ 1 + 2^{1-p},\ 1 + 2 \times 2^{1-p},\ 1 + 3 \times 2^{1-p},\ \ldots,\ 2 - 2^{1-p},\ 2$$

$$2, \qquad\qquad\qquad 4$$

Floating point numbers

$$\left\{ \frac{(-1)^s 2^e m}{2^{p-1}} : s \in \{0, 1\},\ e_{\min} \leqslant e \leqslant e_{\max},\ 2^{p-1} \leqslant m \leqslant 2^p - 1 \right\}$$

Single precision number (a "float")

$$e_{\min} = -126,\ e_{\max} = 127,\ p = 24$$

Double precision number (a "double")

$$e_{\min} = -1022,\ e_{\max} = 1023,\ p = 53$$

Floating point numbers

$\varepsilon_{\mathrm{rel}}$ is the smallest value such that $1 + \varepsilon_{\mathrm{rel}} \neq 1$

Single precision number (a “float”)

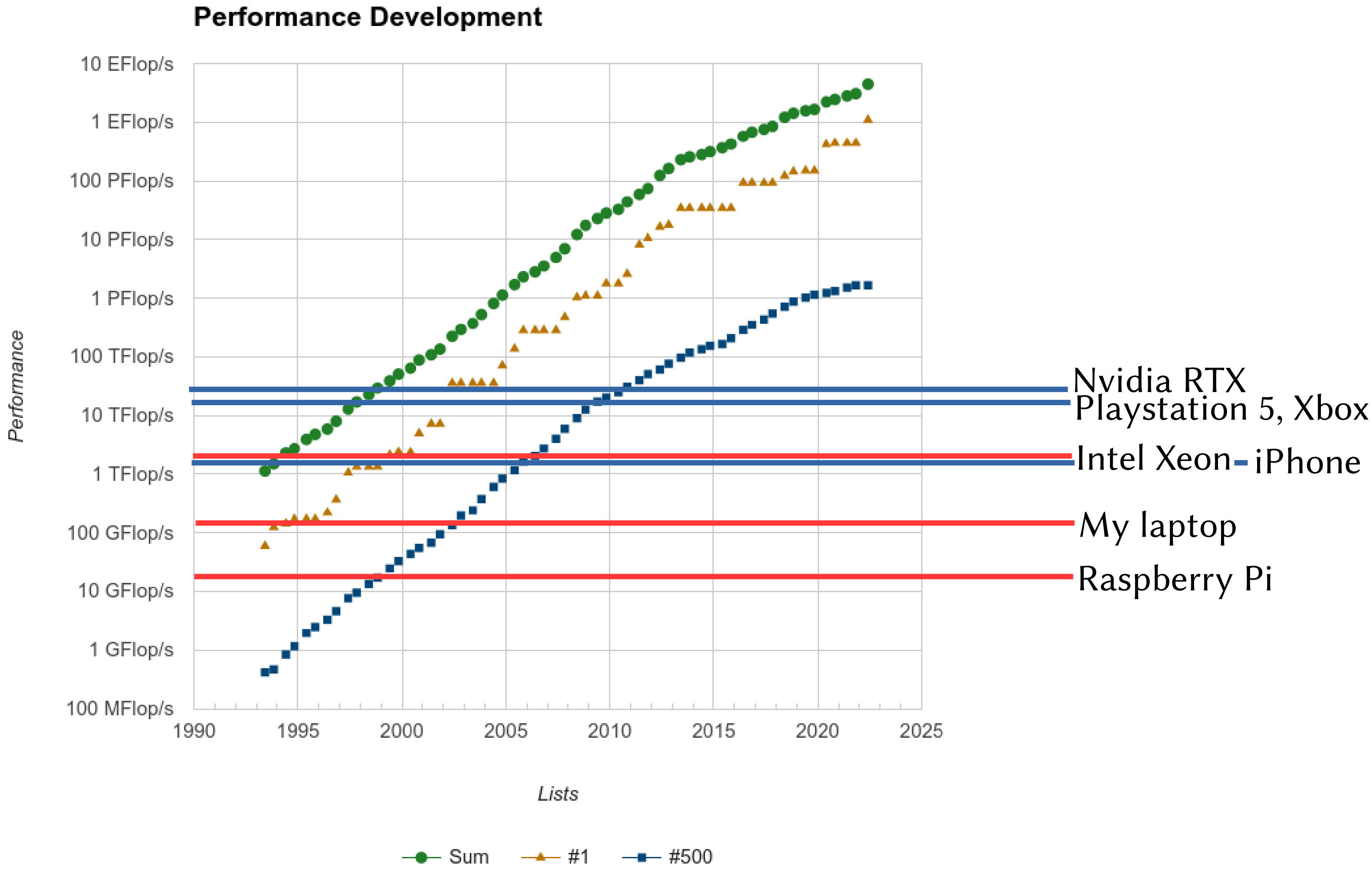
$$\varepsilon_{\mathrm{rel}} \approx 1.2 \times 10^{-7}$$

Double precision number (a “double”)

$$\varepsilon_{\mathrm{rel}} \approx 2.2 \times 10^{-16}$$

Gigaflops/s

Machine	Gigaflops/s
Intel Core i5-8250U (My laptop)	163
Intel Xeon Platinum 8280M	1 612
Raspberry Pi 4B	24
iPhone 13 Pro GPU	1 500
Nvidia RTX 3080	29 768
PS5 GPU	10 280
Xbox Series X GPU	12 500



Performance Development
10 EFlop/s
1 EFlop/s
100 PFlop/s
10 PFlop/s
1 PFlop/s
100 TFlop/s
10 TFlop/s
1 TFlop/s
100 GFlop/s
10 GFlop/s
1 GFlop/s
100 MFlop/s
Performance
1990
1995
2000
2005
2010
2015
2020
2025
Lists
Sum
#1
#500
Nvidia RTX
Playstation 5, Xbox
Intel Xeon
iPhone
My laptop
Raspberry Pi

PHAS0102 Part 1: High-Performance Computing with Python

Running Python

- Anaconda / Miniconda
- Windows Subsystem for Linux
- Google Colab