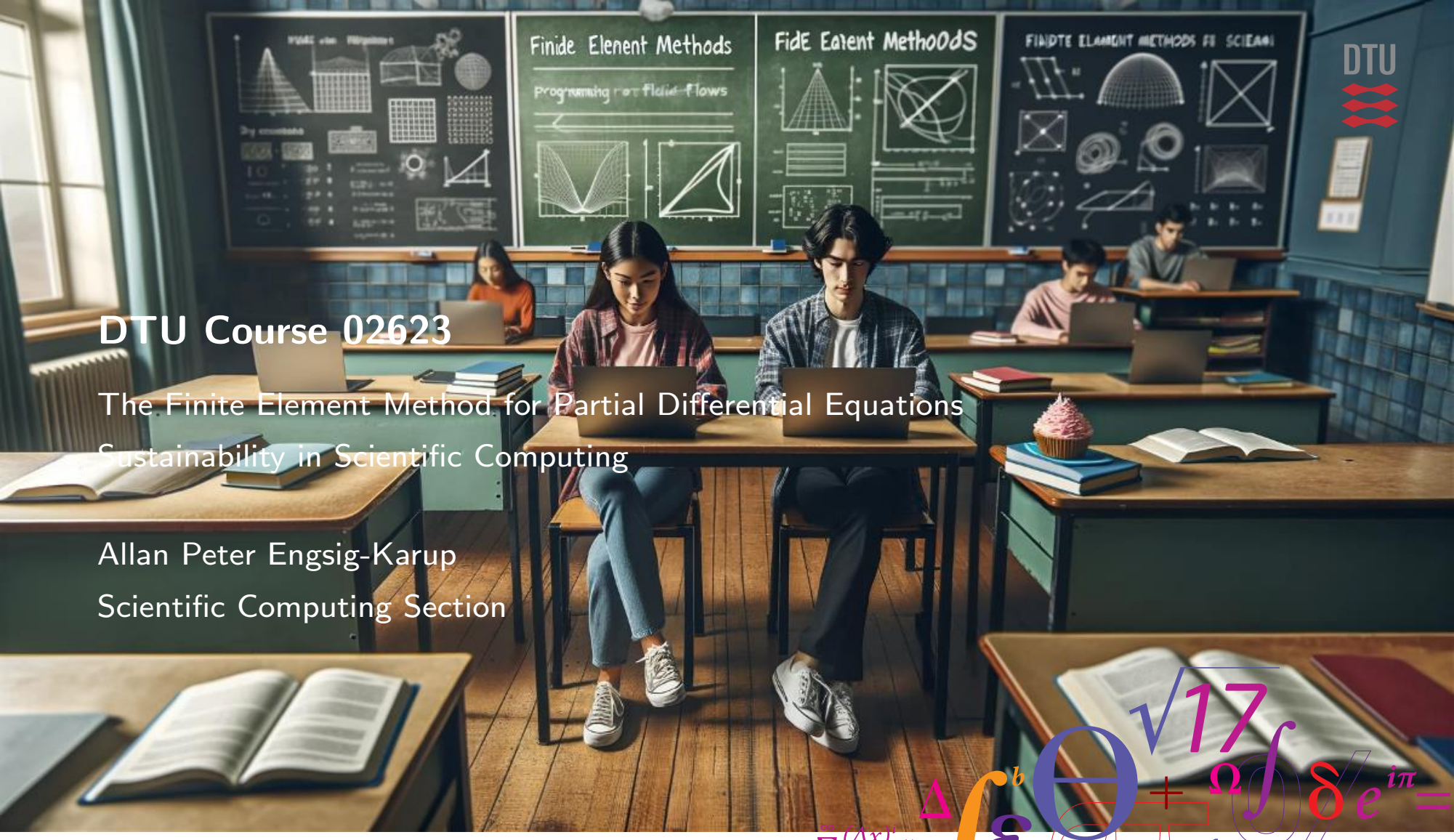


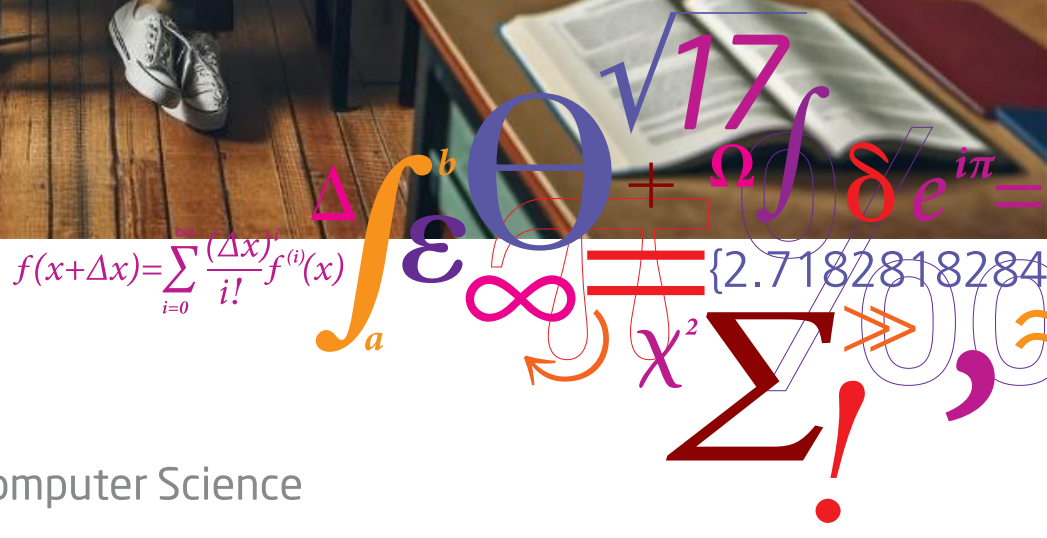
DTU Course 02623

The Finite Element Method for Partial Differential Equations

Sustainability in Scientific Computing

Allan Peter Engsig-Karup

Scientific Computing Section



DTU Compute

Department of Applied Mathematics and Computer Science

Sustainability in Scientific Computing

In this course we seek to contribute illuminating and understanding better means for meeting sustainable development goals through Scientific Computing approaches and reporting.

Hence, in connection with all exercises and poster projects a task is to report measures related to sustainable computing

- co2eq consumption for computations done.
- detail hardware used and formulas for estimating the co2eq consumption.
- if meaningful, relate to one of the United Nations sustainable development goals (Cf. link above, some may apply).

For the week 3 projects, this course gives you as a participant an opportunity to prepare a project that may participate in DTU's Study Conference on sustainability, climate technology, and the environment (GRØN DYST). More information http://www.groendyst.dtu.dk/english.

Sustainability in Scientific Computing

Learn about sustainability....

- International Energy Agency (IEA)
  - World Energy Outlook Report, https://www.iea.org/analysis
  - Data and Statistics, https://www.iea.org/data-and-statistics
- Hardware monitoring programs
  - HWMonitor, https://www.cpuid.com/softwares/hwmonitor.html
- Calculation Methods,
  - https://carbonfund.org/calculation-methods/
  - https://smarterbusiness.co.uk/blogs/how-much-energy-do-my-appliances-use-infographic/
- Calculators
  - https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
  - https://www.rensmart.com/Calculators/KWH-to-CO2
- Other
  - Blue Sky Model, https://blueskymodel.org
  - Energistyrelsen, Key figures, https://ens.dk/service/statistik-data-noegletal-og-kort/noegletal-og-internationale-indberetninger

Week 1 Tasks

Report in a file "ReportWeek1.txt" on

1. CPU time (wall clock time for executing your code)
2. Iteration counts
3. Final DOF
4. Hardware used
5. CO2eq consumption estimate (describe to me the formula used)
6. Error tolerance used (1e-4) and list code for your error measure
7. Describe you adaptive mesh refinement strategy, i.e. how you refine your mesh based on tolerance
8. Other relevant stuff (e.g. what references you have used to decide on how to report, etc.)
9. Prepare your code, so that the script you have written is called "DriverAMR17.m" (similar for other programming languages) so I can execute your code by calling your function and reproduce all of above on my laptop (=same hardware across all groups). See the skeleton code "DriverSustainabilityBenchmarkingWeek1.py" (DO NOT CHANGE THE SCRIPT!).
10. Initial mesh configuration. You should use here x = [0 0.5 1.0], i.e. M=3 for the initial mesh in exercise 1.7.

Week 2 Tasks

Report in a file "ReportWeek2.txt" on

1. Prepare your code, so that the script you have written can be called "`DriverAMR28b.m`" (similar for other programming languages) so I can execute your code and reproduce all of above on my laptop (=same hardware across all groups)
2. CPU time (wall clock time for executing your code, for both program b) "`Driver28b.m`" and program c) "`Driver28c.m`" in Exercise 2.8)
3. Mesh parameters should be "noelms1=40,noelms2=50", report Final DOF
4. Hardware used
5. CO2eq consumption estimate (use the formula discussed in class where you estimate Power [W] for your device and time the solution)
6. Report the $||e||_\infty$ for both program b) and program c) in Exercise 2.8.
7. Answer the question: what can be done to minimize co2 footprint when using scientific computing? Make a list of suggestions (and demonstrate at least one of them with your code).
8. Other relevant stuff (e.g. what new references you have found that related to sustainability, etc.)

Remark, a template for the Driver script will be provided and should be used for the submission.

CO2eq consumption

The CO2eq consumption can be estimated by using the formula

$$CO2eq = t_{CPU} \cdot P \cdot C$$

where units are CO2eq [kg CO_2], time (t_{CPU}) [h], power consumption of device (P) [kW] and the CO_2 intensity (C) [kg CO_2 / kWh].
It may be useful to convert units, such that time is measured in seconds (s) instead of hours (h) and power is measured in Watts (W) instead of kiloWatts (kW) in which case the following formula can be used

$$CO2eq = \frac{t_{CPU}}{3600} \cdot \frac{P}{1000} \cdot C$$

The estimated CO_2 intensity is determined by the power sources that defines the energy mix. In Denmark the cost of electricity in terms of CO_2 is estimated to be 0.285 kg CO_2 per kWh (east Denmark), cf. ENERGINET or via the electricity map, cf. the web app.

In conclusion, we have three key factors in the estimates, time, power consumption and CO_2 intensity.