

A hand holding a glowing lightbulb, symbolizing an idea or energy. The lightbulb is surrounded by a circular network of icons connected by lines, representing various energy and sustainability concepts. The icons include: a solar panel, a wind turbine, a water drop, a leaf, a corn cob, a recycling symbol, an oil rig, a sun, and a laptop with a water drop. The background is a blurred green, suggesting nature.

# Thermodynamics and statistical physics

FYS2160 autumn 2023

Confirm your presence:

<https://nettskjema.no/a/fys2160-h23>

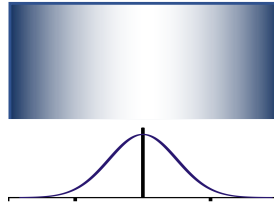
# Brief quiz

menti.com  
5373 6156



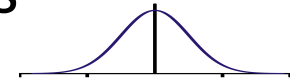
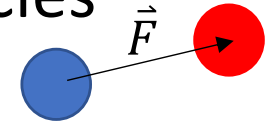
# Thermodynamics

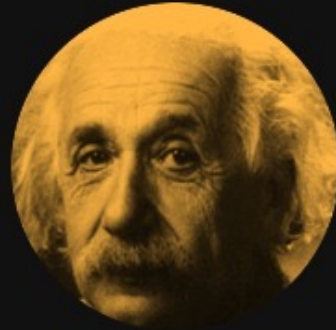
- Macroscopic
- Continuum matter
- Differentiable
- Necessary relations based on some axioms
  - Always true for all matter
  - Necessary tool for theory
  - Always present in applications (climate, environment, engineering,...)
- All properties of matter ( $\Delta H_m$ ,  $\Delta S_v$ ,  $c_v$ ,  $\lambda$ ,  $D$ ) must be measured



# Statistical physics

- Microscopic
- Discrete particles
- Mechanics
- Statistical behaviour of simplified models
- Bottom up explanation of thermodynamics
- Properties of model matter ( $\Delta H_m$ ,  $\Delta S_v$ ,  $c_v$ ,  $\lambda$ ,  $D$ ) can be calculated and measured in simulation





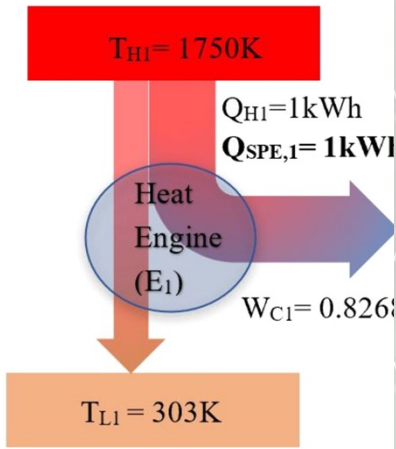
**“A theory is the more impressive the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability. Therefore the deep impression which classical thermodynamics made upon me. It is the only physical theory of universal content concerning which I am convinced that within the framework of the applicability of its basic concepts, it will never be overthrown.”**

~ ALBERT EINSTEIN

# Thermodynamics is important

to understand the climate,  
environmental and  
sustainable processes

and relevant for many jobs in  
industry and planning

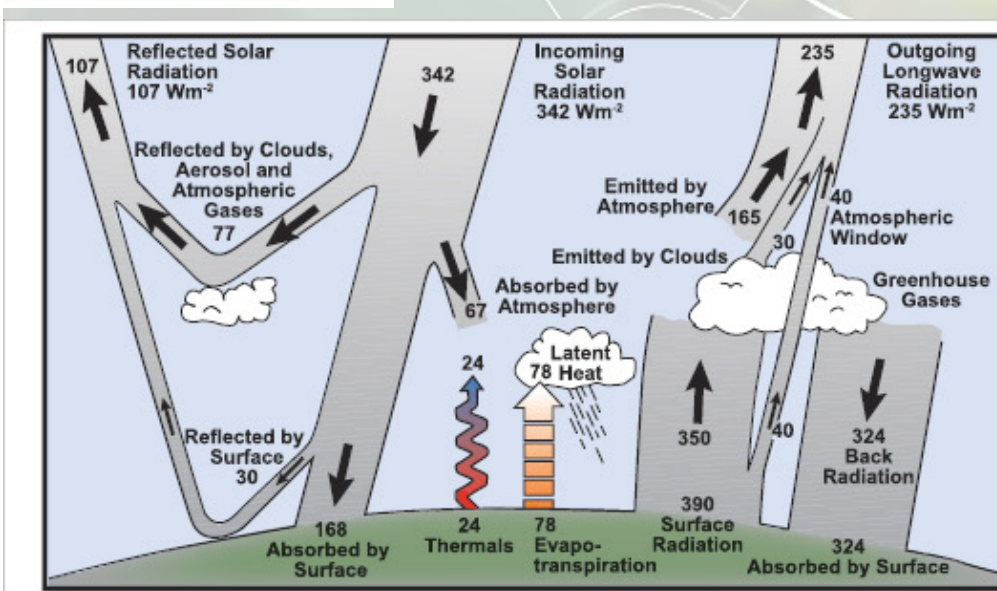


## 2.3 Flows of energy and matter

## 2.5 Investigating ecosystems

**Related topics:**  
 Unit 1.2  
 Unit 1.3  
 Unit 2  
 Unit 4  
 Unit 5  
 Unit 6  
 Internal Assessment

**Objectives:**  
 - Become familiar with the flow of matter and energy along food chains.  
 - Gain familiarity with the carbon and nitrogen cycles.  
 - Learn how to measure biomass and productivity.





Right now, confirm your presence:

<https://nettskjema.no/a/fys2160-h23>

# Teachers this year:

**Vetle, Simon:** problem solving, lab

**Silja:** group sessions, lab

**Pavlo, Luiza, Dag:** lectures, ++

<https://nettskjema.no/a/fys2160-h23>



# Group sessions: Silja

Group sessions: <https://nettskjema.no/a/355060>





# Communication teachers <-> students

- Lectures
  - Physical lectures (+ some digital) and seminars
  - Recorded lectures from 2021 available
    - lecture notes, shorter videos, quizzes
- Astro-discourse: Q&A, discussions
- E-mail: Strictly for personal messages
- Canvas:
  - sign up for labs
  - hand in assignments
  - assignment feedback
- Web page: all else (course material, messages)
- Student representatives

# Student representatives

- Two students who can
  - Receive messages from fellow students
    - About things that do not work
    - What works well
  - Participate in evaluation of the course.
- Student feedback helps us improve!

# Use the textbooks!!



## Introduction to Thermal Physics

**Schroeder Daniel V.**

Heftet / 2021 / Engelsk

FYS2160 23H > Pensum

2023 HØST

- Hjem
- Kunngjøringer
- Oppgaver
- Diskusjoner
- Vurderinger
- Personer
- Sider
- Filer
- Emneoversikt

FYS2160 H23 Termodynamikk og statistisk fysikk > Elektroniske dokumenter

**Elementary Thermal and Statistical Physics Using Python**

✓

**Tittel:** Elementary Thermal and Statistical Physics Using Python  
**Forfatter:** Anders Malthe-Sørensen

📌 Legg til tagger på referansen

Lenker & Tilgjengelighet

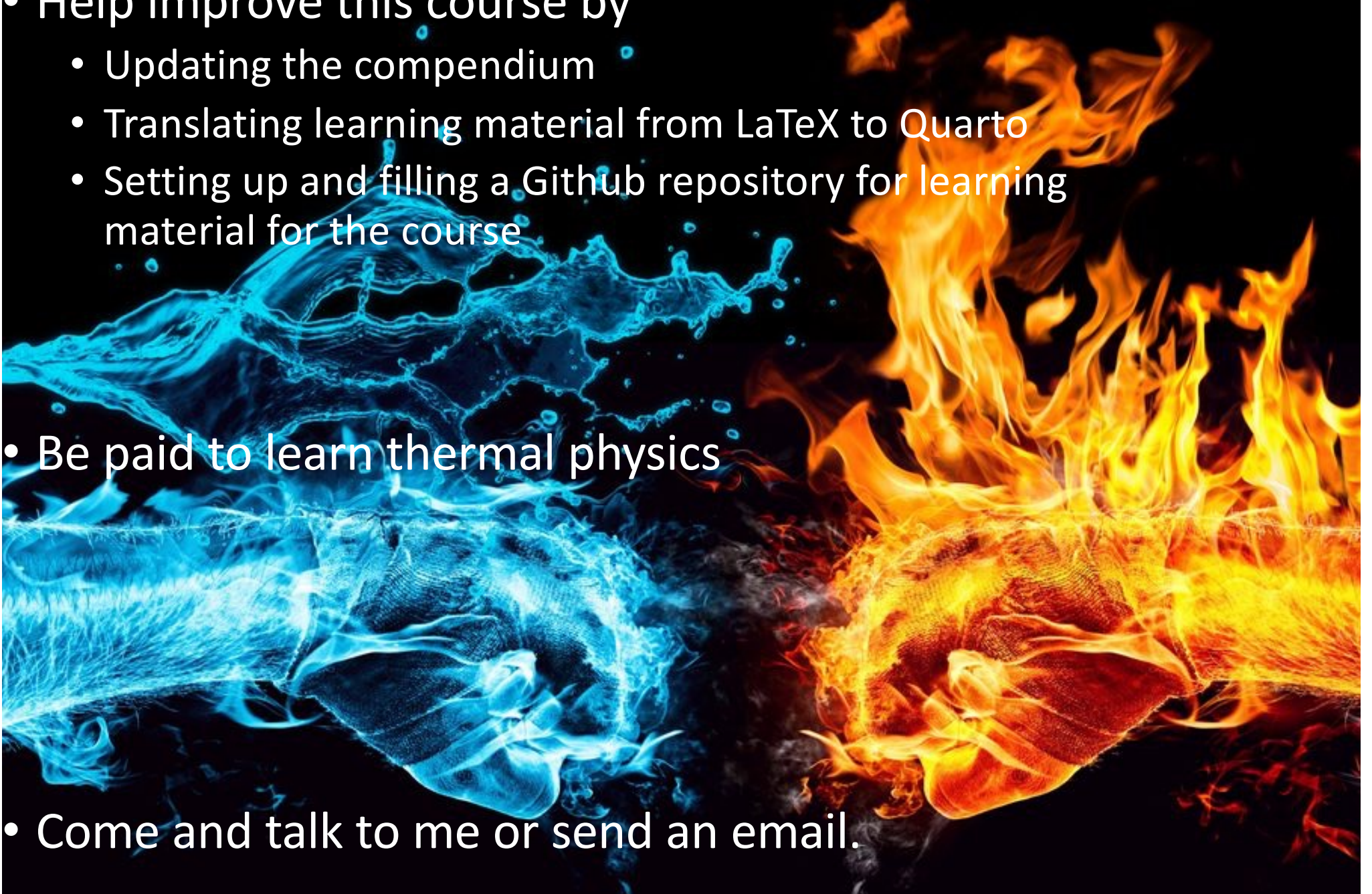
*statphys-python.pdf* Offentlig annoterin

📄 Last ned(pdf)

🔗 Vis

# Job advertisement

- Help improve this course by
  - Updating the compendium
  - Translating learning material from LaTeX to Quarto
  - Setting up and filling a Github repository for learning material for the course
- Be paid to learn thermal physics
- Come and talk to me or send an email.



# Concepts

## Thermal concepts:

energy, heat, temperature  
thermal equilibrium (0<sup>th</sup> law)  
heat capacity  
thermal expansion  
heat conduction  
heat radiation  
latent heat  
work  
1<sup>st</sup> law

Known?

## Thermodynamic concepts:

entropy  
2<sup>nd</sup> law  
mechanical & diffusive equilibrium  
(pressure & particle number)  
enthalpy  
free energy  
diffusion & osmosis

## Statistical mechanical concepts:

randomness  
multiplicity  
probability  
degrees of freedom  
equipartition of energy  
Boltzmann factor  
partition function  
Gibbs factor

# Thermal Concepts Inventory quiz



[Follow the link](#)

Password: **Boltzmann**

**25 minutes**

Answer individually

Discuss answers afterwards

After the break:

- Thermal concepts
- Practical information

<https://nettskjema.no/a/fys2160-h23>

# Thermal Concepts Inventory themes

- Temperature
- Thermal equilibrium
- Energy, work, **HEAT**

## Processes:

- Heating
- Thermal conduction
- Thermal radiation
- Thermal expansion
- Phase transition (melting, vaporisation)
- Frictional heating (Joule, solid & liquid friction)

## Material properties:

- Heat capacity
- Thermal conductivity
- Emissivity / absorptivity (albedo)
- Thermal expansion coefficient
- Latent heat
- Viscosity

$$T$$

$$T_1 = T_2$$

$$E, W, Q$$

$$\Delta Q = C \Delta T$$

$$J_Q = \frac{dQ}{A dt} = -\lambda \frac{dT}{dx}$$

$$J_Q = \sigma T^4$$

$$\Delta V = \beta V \Delta T, \quad \Delta L = \alpha L \Delta T$$

$$Q_l = Q_s + L_m, \quad T = \text{const}$$

$$\Delta Q = R \Delta q, \quad \mu F_{\perp} \Delta x, \quad \eta \frac{\partial \Delta x}{\partial y}$$

$$c_p, c_V = \frac{\Delta Q}{\Delta T}$$

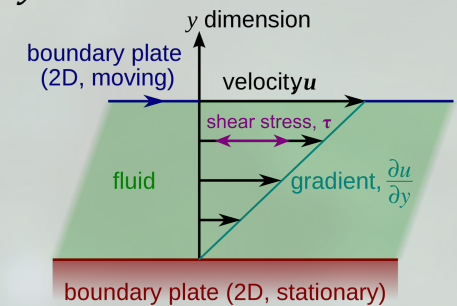
$$\lambda$$

$$e = a$$

$$\beta \equiv \frac{\Delta V/V}{\Delta T}, \quad \alpha \equiv \frac{\Delta L/L}{\Delta T}$$

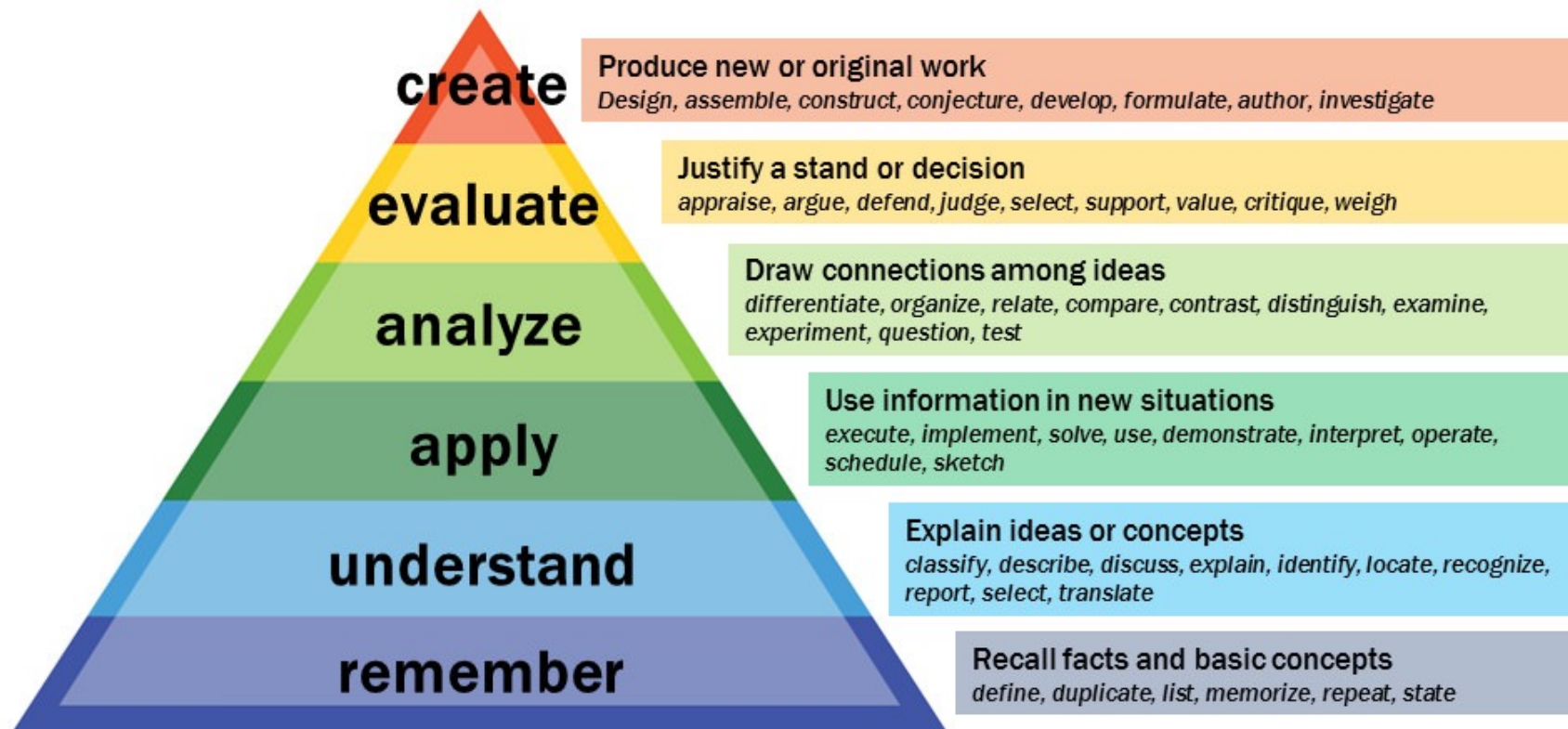
$$L_m, L_v$$

$$\frac{F}{A} = \tau = \eta \frac{\partial u}{\partial x}$$



# We expect you to climb!

## Bloom's Taxonomy





Høst 2023

- Lectures
- Obligs\_Labs
- Weekly exercises

FYS2160 - Termodynamikk og statistisk fysikk

## Semesterside for FYS2160 - Høst 2023

[Timeplan](#) →

[Eksamen: Tid og sted](#) →

### Faglærere

- Dag Kristian Dysthe
- Pavlo Mikheenko
- Silja Borring Låstad
- Luiza Angheluta-Bauer
- Vette Amundsen Vikenes
- Simon Phillip Coolil

### Canvas

Dette emnet bruker Canvas i undervisningen. [Se tips og veiledninger for Canvas.](#)

[Logg på Canvas](#) →

### Beskjeder

[Ny beskjed](#)

### Important links

Publisert 21. aug. 2023 14:40

### [Welcome to FYS2160 Thermodynamics and statistical physic](#)

Publisert 17. aug. 2023 14:39

### [Obligatorisk oppmøte til første forelesning](#)

Publisert 15. aug. 2023 10:15

→ [Se flere beskjeder](#)

### About the course

→ [In general about the course](#)

→ [Detailed week plan](#)

[Course web page](#)

# Assignments

## Weekly excercises

- Numerous types
  - analytical calculations
  - numerical
  - data analysis
  - conceptual questions
- Problem solving workshop (regneverksted) for aid

## Experiment + numeric lab

- 8 hour lab day
- hand in report before you leave
  - Formats:
    - PDF (preferably LaTeX)
    - Jupyter notebooks
    - Matlab live scripts
- reports must be passed to take exam

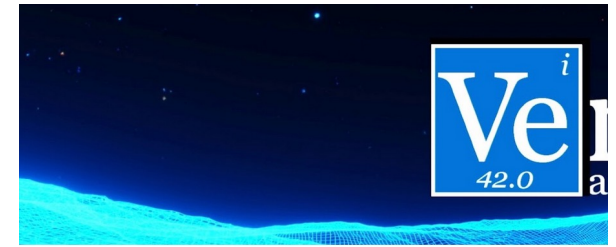
## Oblig (obligatory assignments)

- 3 of 4 must be passed to take exam
- Hand in
  - On Canvas
  - Formats:
    - PDF (preferably LaTeX)
    - Jupyter notebooks
    - Matlab live scripts
- Feedback on Canvas

# Lab exercises

- 2 parts: Experiment and numerical simulations
- Duration: 8 hours
- Groups of 2 students work together
- Hand in report before you leave. Pass is compulsory!
- First lab: weeks 39 & 40:
  - Tue, Wed, Thu, 08-16
- Important to participate in Molecular Dynamics exercises in week 36-38!!!
- Soon: sign up for specific time slots on Canvas

# Watch this video!



Veritasium ✓

@veritasium 14,1 mill. abonnenter 370 video

An element of truth - videos about science, ed

What does the Earth get from the sun?

Spill av (k)

0:34 / 27:14 • Intro >

What does the Earth get from the sun?