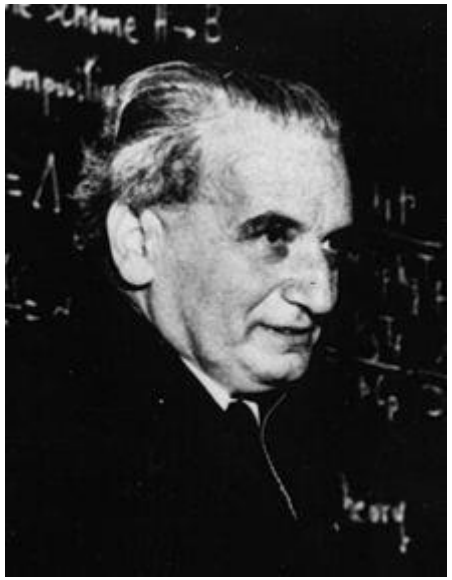
Aalto University
School of Engineering

COE-C2004 - Materials Science and Engineering

Prof. Junhe Lian
Wenqi Liu (Primary Teaching Assistant)
Rongfei Juan & Sayoojya Prasad (Teaching Assistants)

“Scientists discover the world that exists; engineers create the world that never was.”

— Theodore Von Karman



https://en.wikipedia.org/wiki/Theodore_von_K%C3%A1rm%C3%A1n

The starting point

Engineers make things.

They make them out of **materials,** using **processes.**

- What do they need to know?
- **Perspective** of the world of materials and processes
- **Understanding** material properties
- An ability to **select**
- **Information** and **tools**

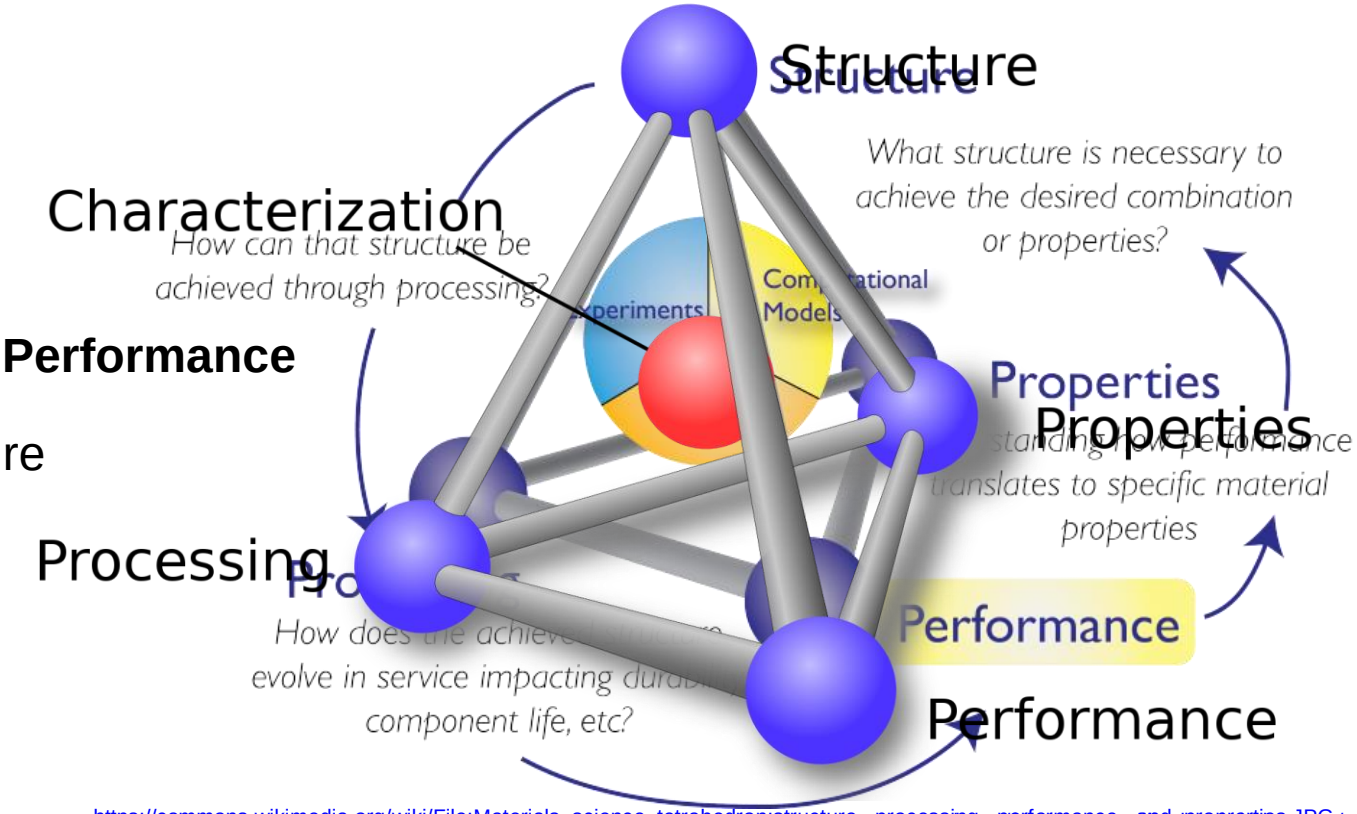
https://storymaps.arcgis.com/

The starting point (cont.)

Before engineers make things,

the scientists need to understand the materials and design materials.

- What do they need to know?
  - **Structure** of materials
  - How structure dictates **properties & Performance**
  - How **processing** can change structure
  - **Understanding** the correlation
  - A **toolkit** to design materials



https://commons.wikimedia.org/wiki/File:Materials_science_tetrahedron;structure,_processing,_performance_and_properties.JPG

Who am I?

B.Sc.
(2002-2006)

M.Sc. & PhD & Group lead
(2006-2018)

Visiting & Research Affiliate
(2015, 2018 – present)

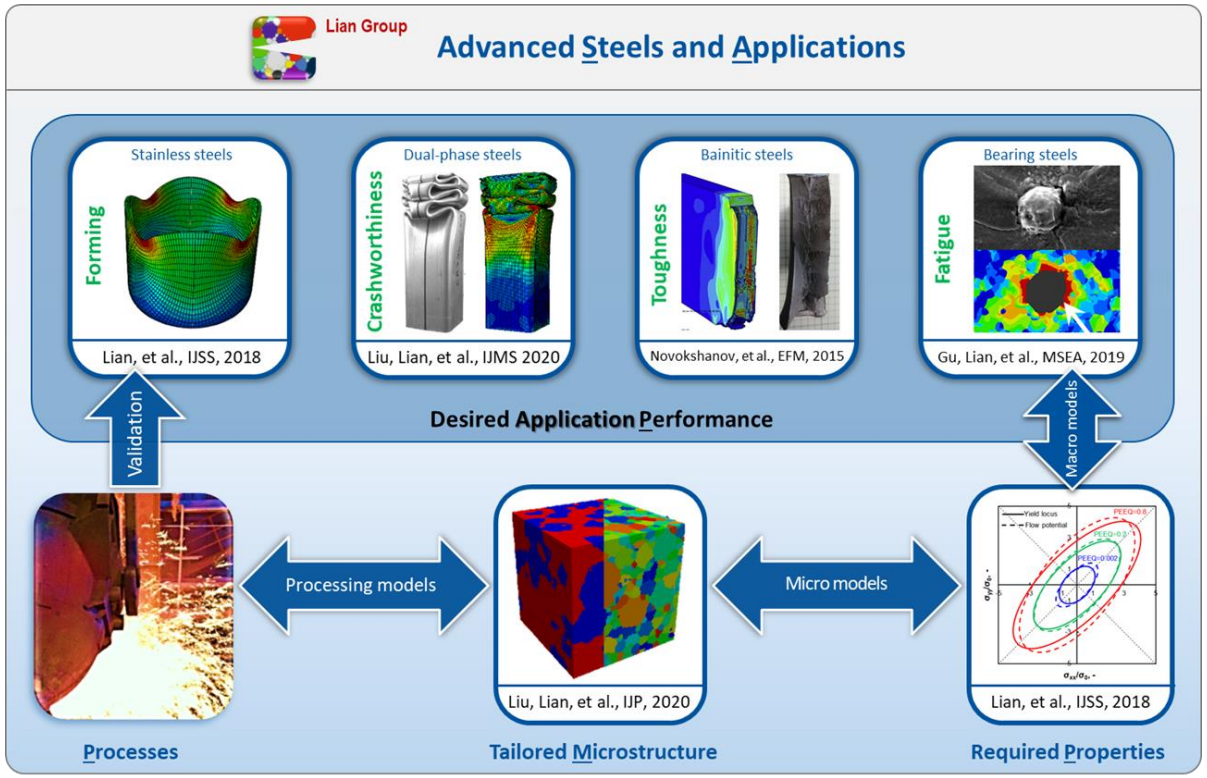
Assistant Professor
(2018 – present)

Focuses

- **ICME** for steels
- **Crashworthiness** of DP steels
- Static and dynamic **toughness** transition behavior
- **Forming** and machining
- Plastic anisotropy, instability, **damage** and fracture
- Material constitutive **modeling**
- **Microstructure** characterization
- Synthetic **virtual microstructure**
- Microscale testing (nano-indentation)
- **Crystal plasticity** modeling
- Microstructure **design**
- Safety of Lithium-ion **batteries**

Hobbies

- Traveling & Food
- Table tennis & Billiard
- Reading & Music



https://www.researchgate.net/lab/Junhe-Lian-Lab

Who are you?

A camera game!

- I will start with one “who” question, and anyone that fits will get picked.
- You will then turn on your camera and make a short introduction of yourself (name, location, interests, hobbies, etc.)
- You will start another “who” question and pick your successor.
- We are trying to get everyone picked and the ones left over will make a conclusion introduction.
- Let’s go!

Materials Science & Engineering

Course Objective...

Introduce fundamental concepts in Materials Science & Engineering

Learning outcomes:

After the course the student shall **be able**:

- to **distinguish** and **explain** terms in materials science
- to **relate** material structure to properties
- to **understand** the influence of processes on structures
- to **analyze** deformation, strengthening and failure mechanisms, like brittle and ductile fracture, fatigue, etc.
- to **relate** diffusion, precipitation and phase transformation mechanisms to microstructural changes in materials
- to **understand** and **use** the computational materials concepts and tools
- to **read** materials science literature and journals

Study materials

Textbook

William D. Callister, Jr. and David G. Rethwisch,

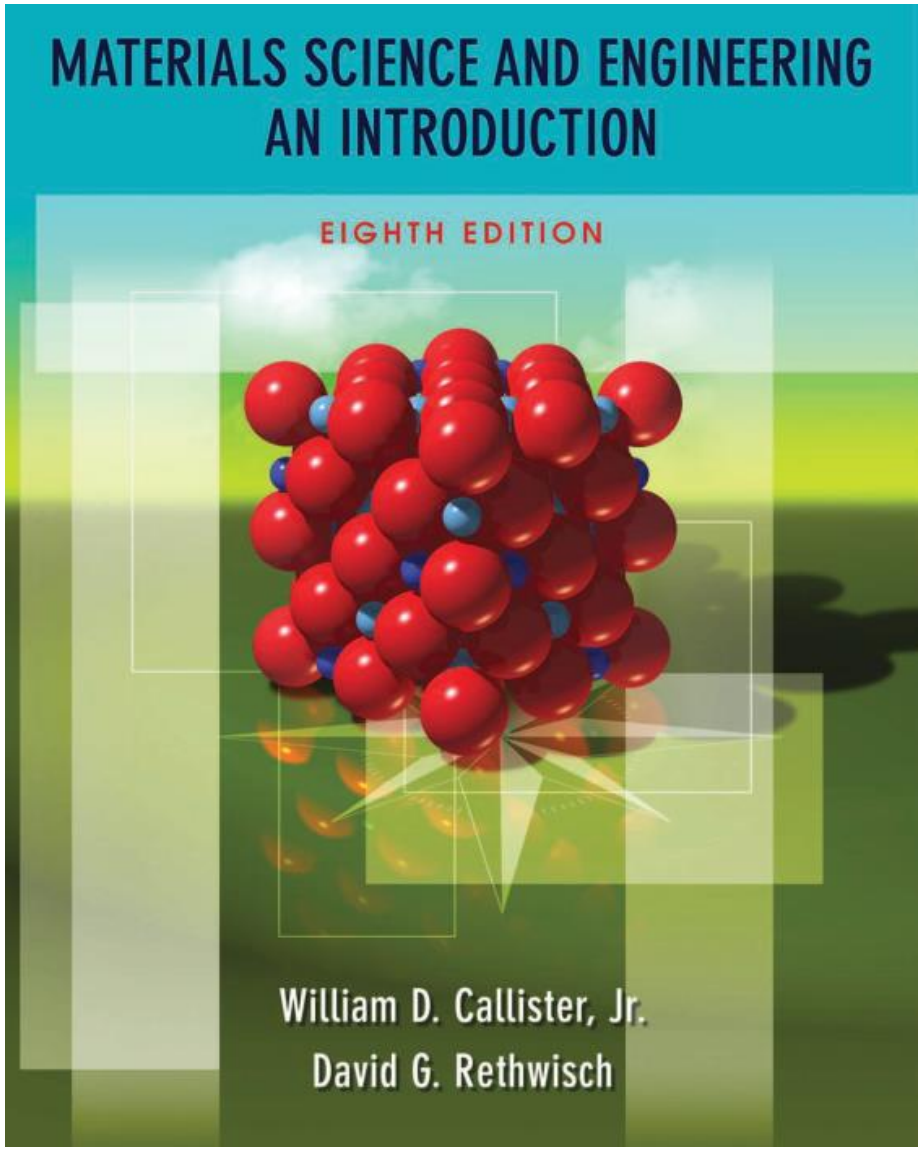
Materials science and engineering: an introduction (8th edition recommended).

You can visit Aalto-Finna (aalto.finna.fi) webpage, log in, and search for this material. Several editions of the book are available in the Aalto Library. Make sure the books are available before you visit the library to borrow.

R. E. Smallman and A. H. W. Ngan,

Physical Metallurgy and Advanced Materials (7th Edition) and Modern Physical Metallurgy (8th edition)

This books are available on the Aalto-Finna website as e-books for Aalto credentials.



http://kaizenha.com/wp-content/uploads/2016/04/Materials-Textbook-8th-Edition.pdf

Class structure & times

- **Lectures** (https://aalto.zoom.us/j/62428835336)
  Mondays and Tuesdays 10:15 – 12:00
  Participation with active discussion and interaction during the course
- **Exercises** (https://aalto.zoom.us/j/62428835336)
  Thursdays 10:15 – 12:00
  Exercises on solving learning outcome related tasks and computational extension of the course content
- **Weekly assignments** (https://mycourses.aalto.fi/course/)
  Publish: Mondays
  Submission DL: 18:00 on Sundays
- **Q&A time** (https://aalto.zoom.us/j/62428835336)
  Tuesdays 16:30 – 18:00
- **General discussion** (https://mycourses.aalto.fi/mod/forum/)
  Anytime to participate; central times for replies are afternoons on Wed/Thu/Fri.
- **Exam** (Final week)

Independent reading & learning
Individually or in a group

Lectures & assignments

Week 1 (Nov 1 – 7) Introduction and material structures

Assignment 1: Ch. 1-4

Week 2 (Nov 8 – 14) Mechanical properties of metals

Assignment 2: Ch. 6-7

Week 3 (Nov 15 – 21) Failure of metals and Computational modeling

Assignment 3: Ch. 8, 17

Week 4 (Nov 22 – 28) Diffusion, phase diagram, and phase transformation

Assignment 4: Ch. 5, 9-10

Week 5 (Nov 29 – Dec 5) Physical properties of materials and sustainability

Assignment 5: Ch. 12, 18-22

Week 6 (Dec 6 – 12) Material processing and summary

Assignment 6: Ch. 11, 13, 15

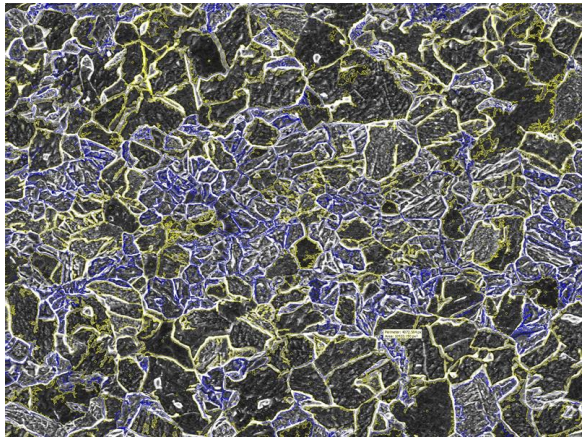
Exercises I – II

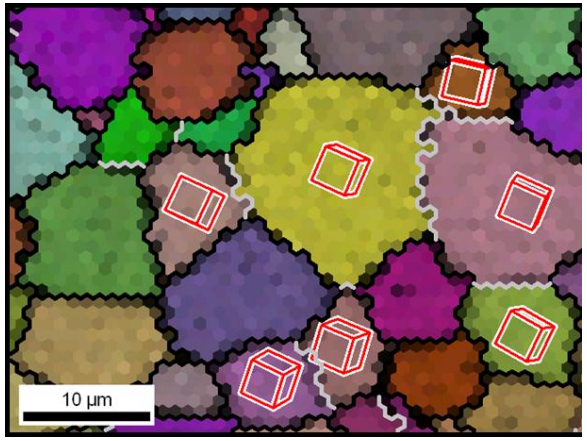
Microstructure **A**nalysis and **C**haracterization

ImageJ

Image Processing & Analysis in Java

TEX

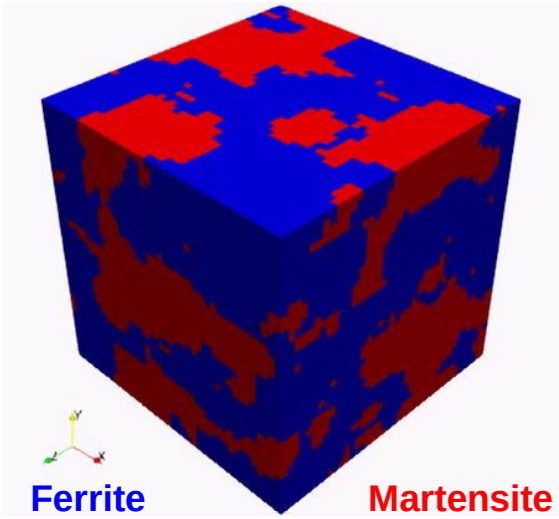


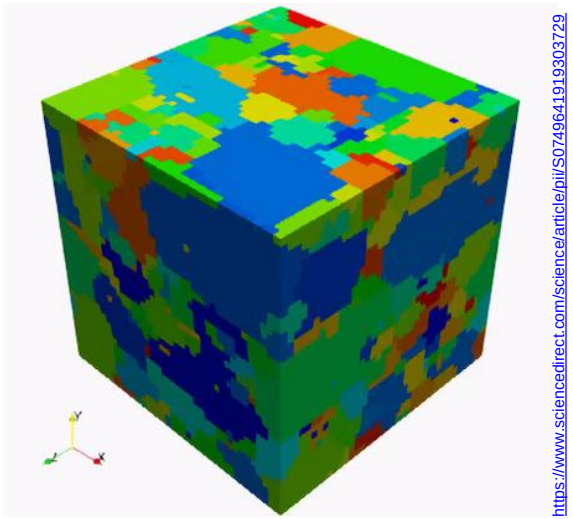


RVE – **R**epresentative **V**olume **E**lements

DREAM.3D

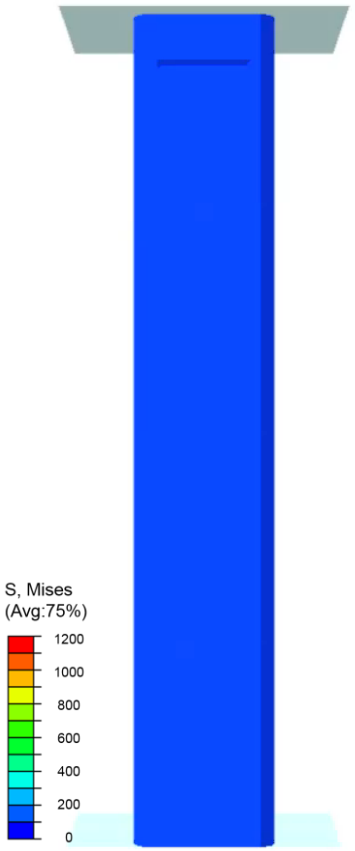
BlueQuartz Edition





https://www.sciencedirect.com/science/article/pii/S0749641919303729

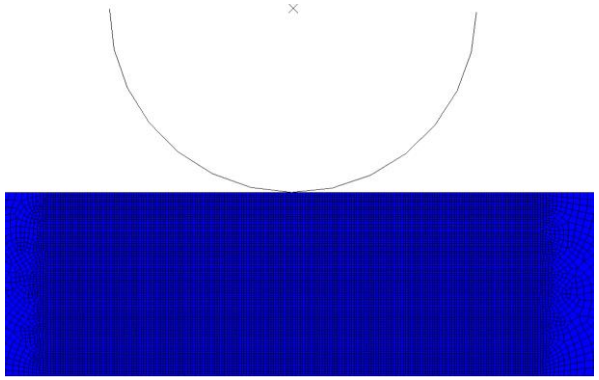
Exercises III – IV



https://www.sciencedirect.com/science/article/pii/S0020740319327961

CDM – **C**ontinuum **D**amage **M**echanics

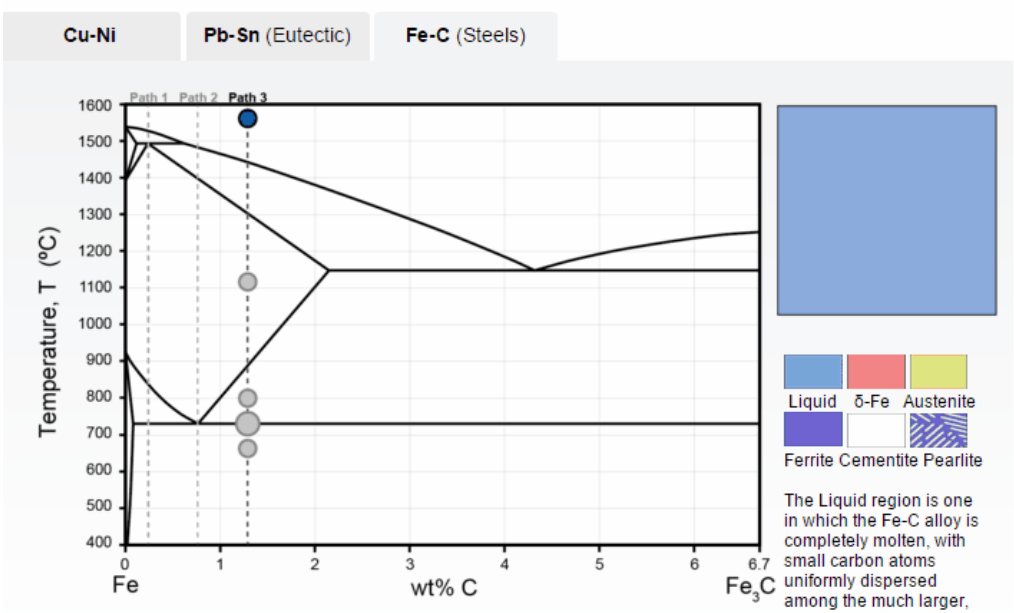
SIMULIA ABAQUS



https://www.sciencedirect.com/science/article/pii/S0013794419304503

Phase **D**iagram and **P**hase **T**ransformation

Thermo-Calc Software

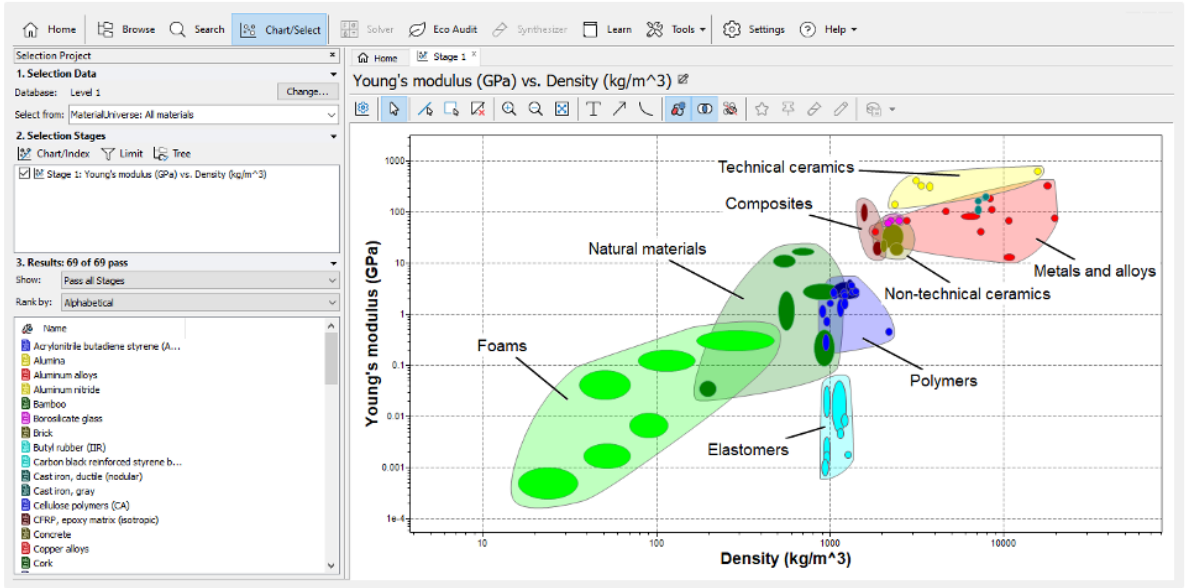


https://www.grantadesign.com/materials-education/bringing-materials-science-engineering-to-life/

Exercises V – VI

SEM – **S**election of
Engineering **M**aterials

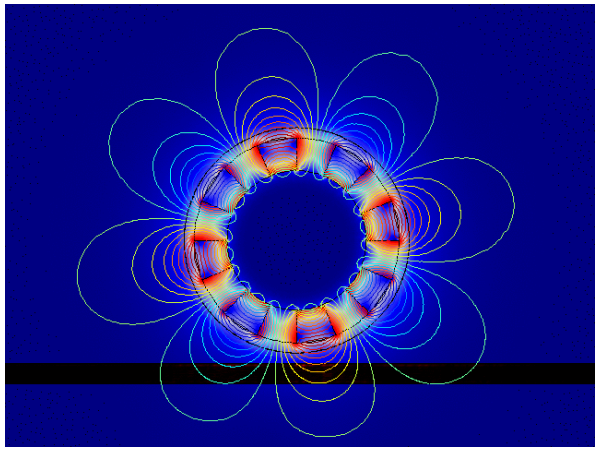
GRANTA EduPack



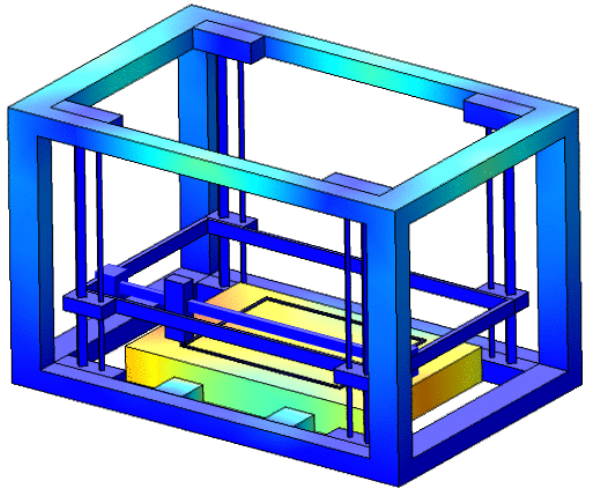
https://www.ansys.com/products/materials/granta-edupack/

Multiphysics **M**odeling
for thermal, mechanical,
magnetic coupling

COMSOL MULTIPHYSICS®



https://www.comsol.com/model/electrodynamic-wheel-magnetic-levitation-in-2d-44871



http://multiphysics-cae.blogspot.com/2016/06/3d-printer-mechanism-simulation.html

Course grade

- 10 points for participation

  0.5 points x 12 ***lectures/seminars***

  0.5 points x 6 ***exercises***

  1 point for ***forum*** *activities*
- 40 points quality of tasks

  (5-7) points x 6 weekly ***assignments***
- 50 points on **exam**
- 10 points on **extra activities**

  5 points on a computational task (details given during Exercise sessions)

  5 points on an essay task (details given during Exercise sessions)

Total	Grade
≥90	5
≥80	4
≥70	3
≥60	2
≥50	1
<50	0

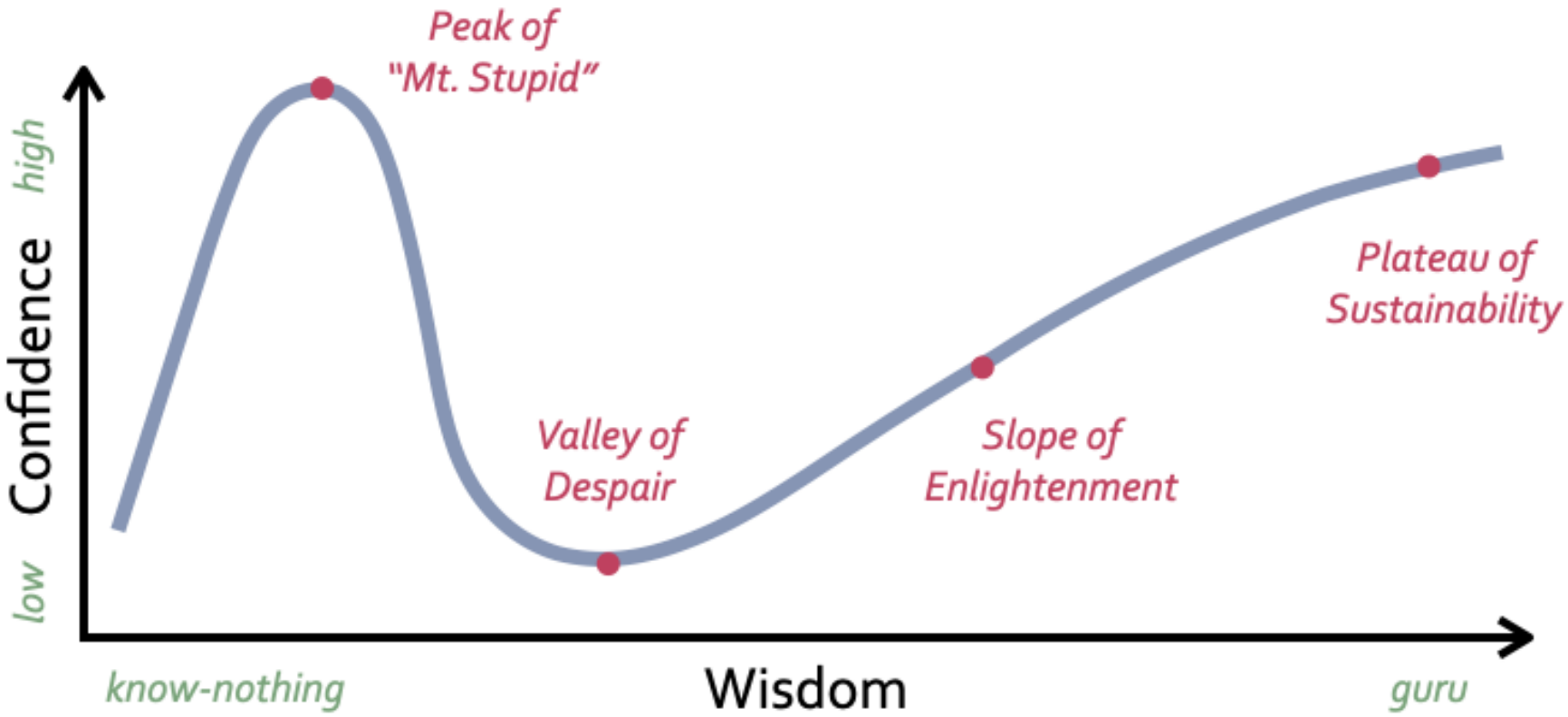
Questions?

- Use your real name to attend the course!
- Use the Zoom Chat function or raise your hands!
- Please avoid emails and use the “General discussion” on MyCourses!

Tip I

https://elearningindustry.com/iceberg-right-ahead-why-training-sinks-doesnt-work

Tip II



https://dorsaamir.medium.com/modest-advice-for-new-graduate-students-b0be6b8dbc22

Tip III

https://revisesociology.com/2017/08/19/the-10000-hour-rule/