



Aalto University
School of Engineering

MEC-E1070

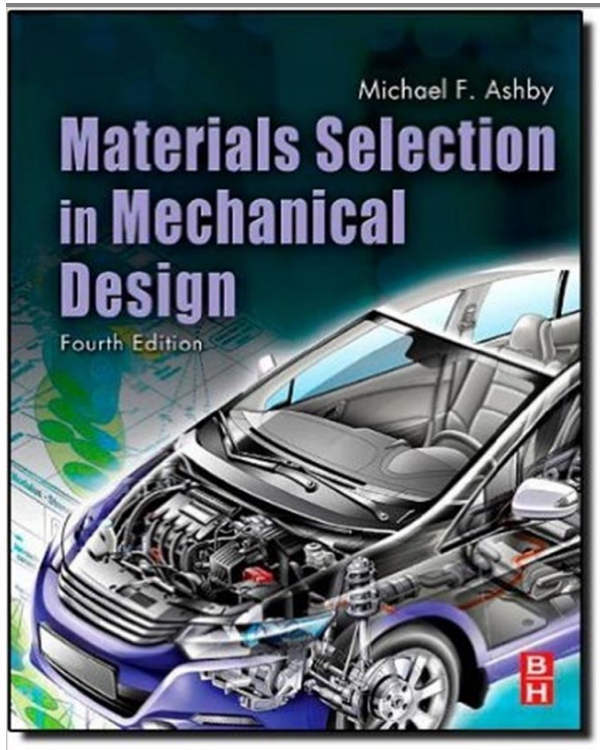
Selection of Engineering Materials

Prof. Junhe Lian, Prof. Sven Bossuyt
course assistant Zinan Li

Textbook and software

Textbook

Ashby, Michael F.
Materials Selection in Mechanical Design
(recommended editions 4th or 5th).



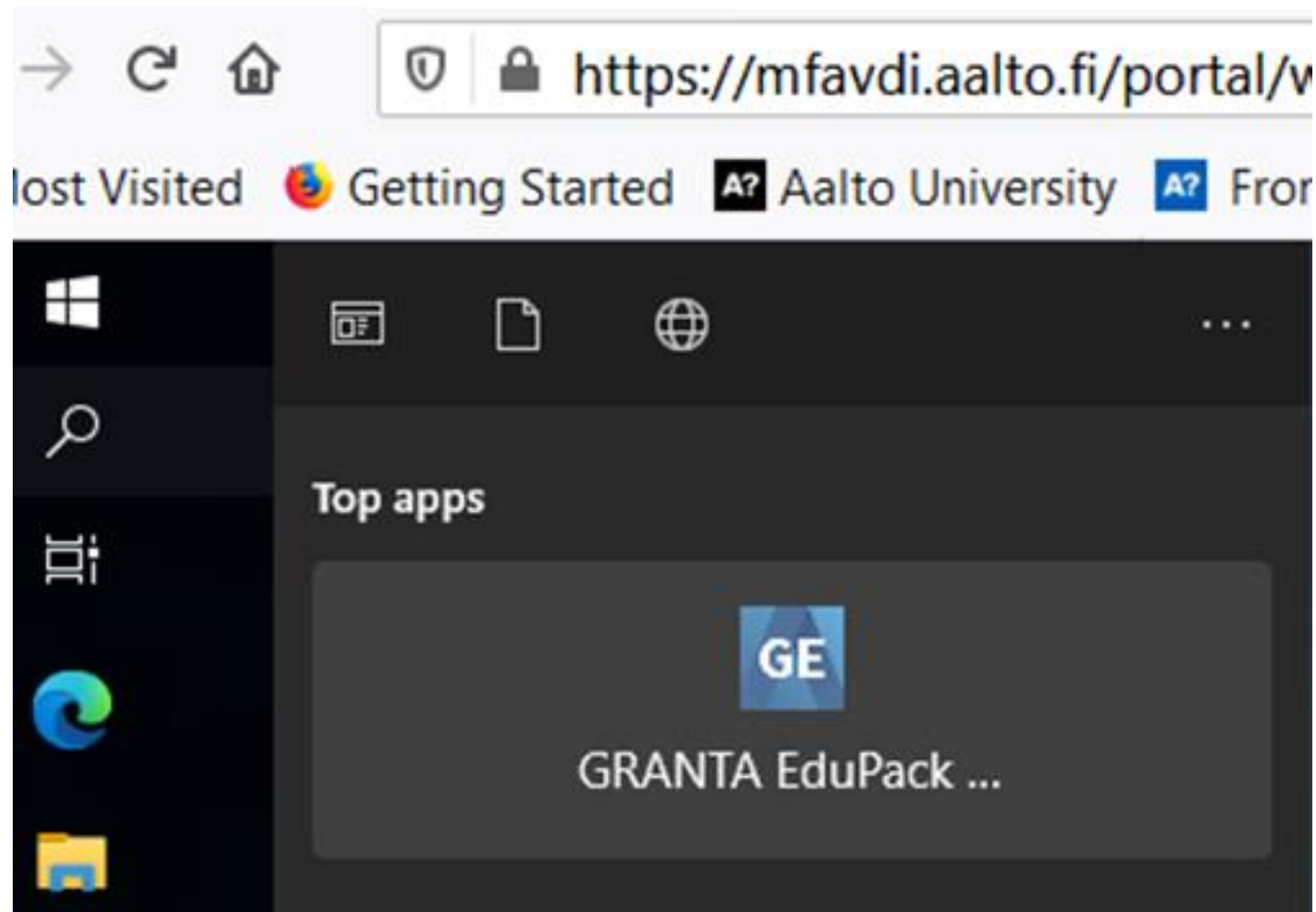
Software

GRANTA EduPack
(was Cambridge Engineering Selector,
from Granta Design Software, now part of ANSYS)



Access to the software

Instruction files on MyCourses



GRANTA EduPack 2023 R2

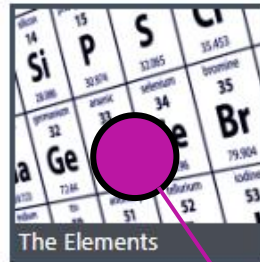
[quick start](#) [★ what's new](#) [+ add database](#) [extra databases](#)

Databases

Introductory

Level 1, general

- Schools, **1st year** college
- **69** materials, **74** processes



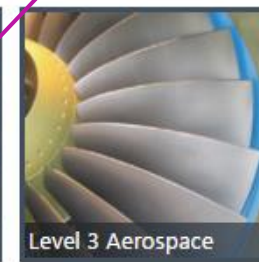
Level 2, general

- **1st-3rd year** students of Engineering, Materials Science and Design
- **100** materials, **116** processes

Advanced

Level 3, general

- **3rd-4th year, masters and research**
- **4169** materials, **247** processes





The Elements Database

- Schools-University students
- **149** records, periodic table

Changing database - different levels

Level 2

 change database  first steps

1. Select a table

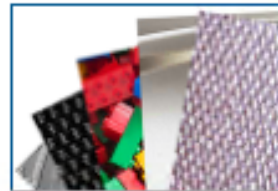
MaterialUniverse >

ProcessUniverse

Reference

Producers

2. Filter by subset





All Materials



Foams

Level 3

 change database  first steps

1. Select a table

MaterialUniverse >

ProcessUniverse

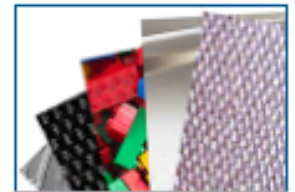
Reference

Producers

Shape

Structural Sections

2. Filter by subset



All Materials



Composites

Intuitive navigation

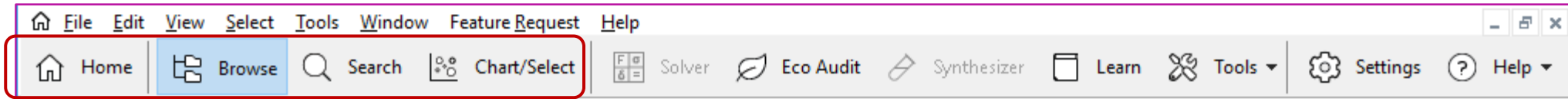
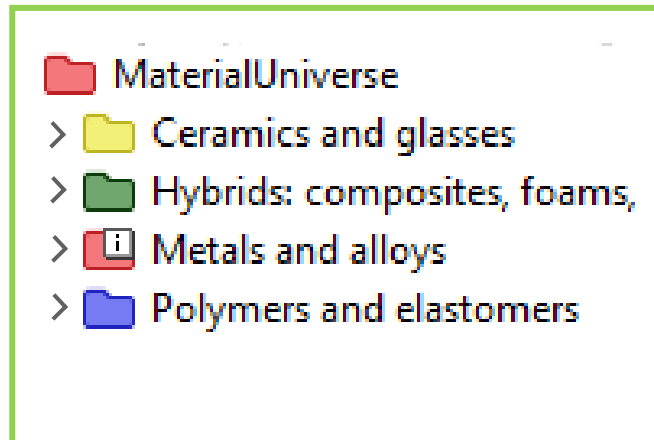


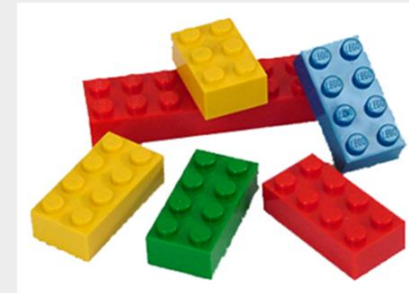
Table: **MaterialUniverse** ▼

Subset: **All materials** ▼



Acrylonitrile-butadiene-styrene (ABS)

The material. ABS (Acrylonitrile-butadiene-styrene) is tough, resilient, and easily molded. It is usually opaque, although some grades can now be transparent, and it can be given vivid colors. ABS-PVC alloys are tougher than standard ABS and, in self-extinguishing grades, are used for the casings of power tools.



General properties

Density	i	1.01e3	-	1.21e3	kg/m ³
Price	i	* 2.5	-	3	USD/kg
Date first used	i				1937

Mechanical properties

Young's modulus	i	1.1	-	2.9	GPa
Yield strength	i	18.5	-	51	MPa
Tensile strength (elastic limit)	i	27.6	-	55.2	MPa
Elongation	i	1.5	-	100	% strain
Hardness - Vickers	i	5.6	-	15.3	HV
Fatigue strength at 10 ⁷ cycles	i	11	-	22.1	MPa
Fracture toughness	i	1.19	-	4.29	MPa.m ^{1/2}

and...

[Thermal properties](#)

[Electrical properties](#)

[Optical properties](#)

[Processability](#)

[Eco properties etc.](#)

[Links to Processes](#)

The Search function

Search

Titanium

Acrylic (PMMA)

Polymethyl methacrylate (Acrylic, PMMA)

The material. When you think of PMMA, think transparency. Acrylic, or PMMA, is the thermoplastic that most closely resembles glass in transparency and resistance to weathering. The material has a long history: discovered in 1872, first commercialized in 1933, its first major application was as cockpit canopies for fighter aircraft during the second World War.

Compositional summary ⓘ
 $(\text{CH}_2-\text{C}(\text{CH}_3)\text{COOCH}_3)_n$

General properties

Density	ⓘ	1.16e3	-	1.22e3	kg/m ³
Price	ⓘ	* 3.14	-	3.74	USD/kg
Date first used	ⓘ				1933

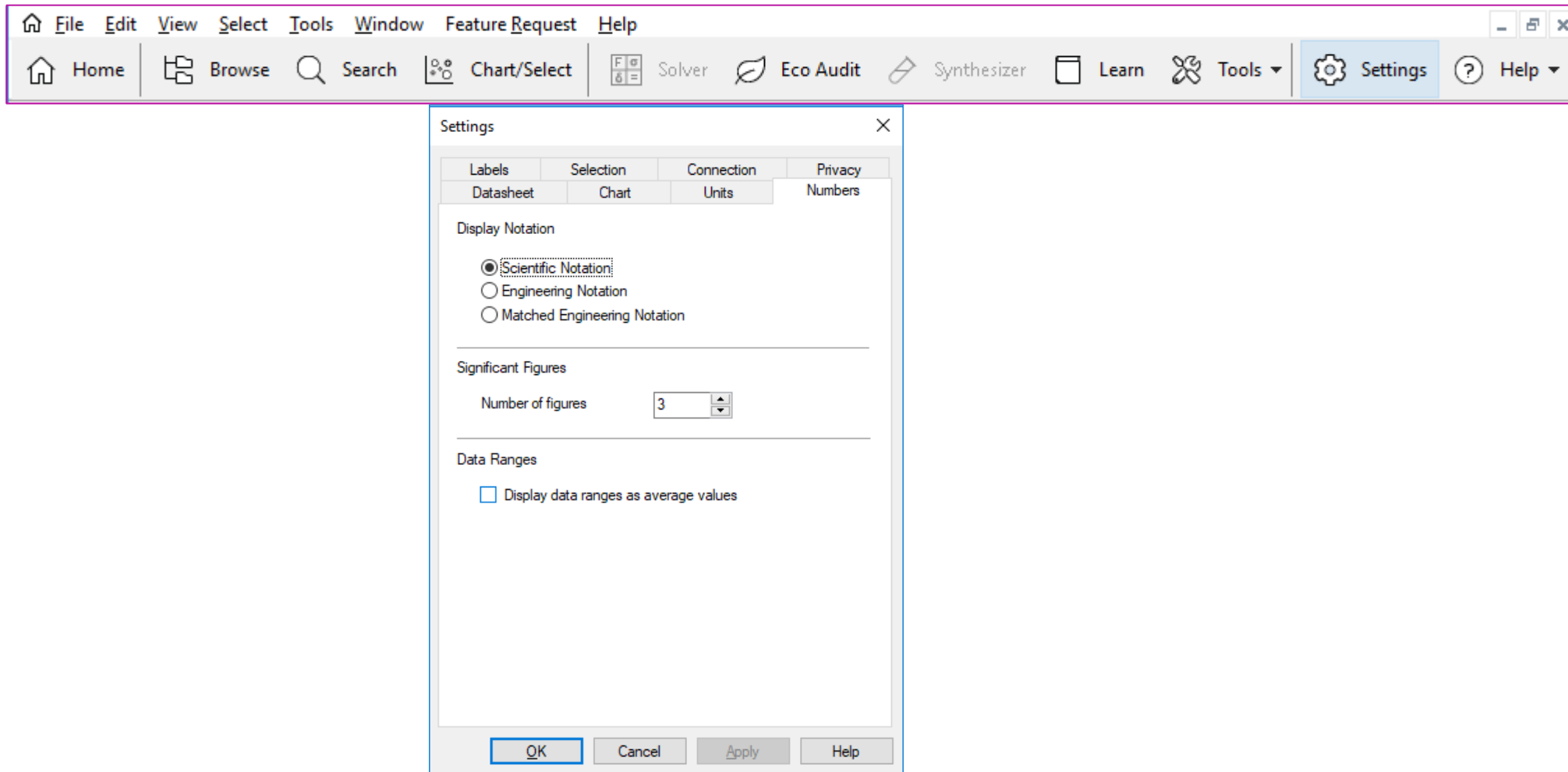
Mechanical properties

Young's modulus	ⓘ	2.24	-	3.8	GPa
Yield strength (elastic limit)	ⓘ	53.8	-	72.4	MPa
Tensile strength	ⓘ	48.3	-	79.6	MPa
Elongation	ⓘ	2	-	10	% strain
Hardness - Vickers	ⓘ	16.1	-	21.9	HV
Fatigue strength at 10 ⁷ cycles	ⓘ	* 15.2	-	32.7	MPa

Caption Car rear light casing. © Chris Lefteri

- Not sensitive to CASE but to spelling
- Searches all data-tables
- Operators AND, OR, NOT, * ...
- Categorizes all results
- Highlights search term in datasheet

Changing the data settings (units etc.)



Accessing the science behind the properties

Acrylonitrile-butadiene

The material. ABS (Acrylonitrile-butadiene) is tough, resilient, and easily molded. It is although some grades can now be transparent. ABS can be given vivid colors. ABS-PVC alloys are standard ABS and, in self-extinguishing for the casings of power tools.

General properties

Density		1.01e3	-
Price		* 2.5	-
Date first used			-

Mechanical properties

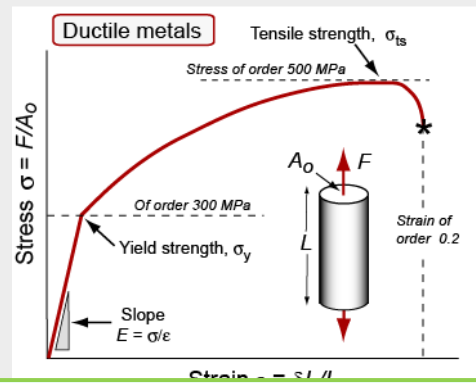
Young's modulus		1.1	-
Yield strength		18.5	-
Tensile strength (elastic limit)		27.6	-
Elongation		1.5	-
Hardness - Vickers		5.6	-
Fatigue strength at 10 ⁷ cycles		11	-
Fracture toughness		1.19	-

Young's modulus

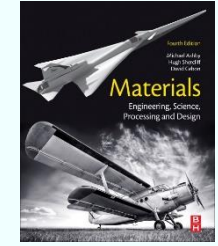
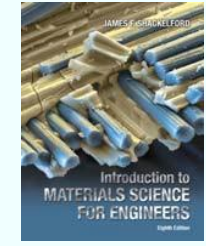
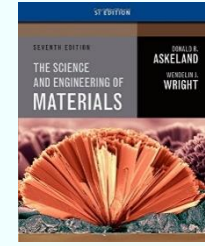
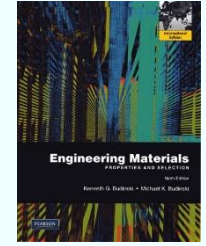
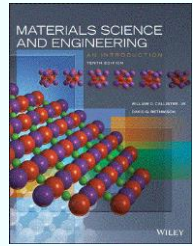
Definitions and measurement.

Figure 1 shows a typical tensile stress-strain curve. The initial part is linear (Hooke's law), and it is elastic, meaning that the strain is recoverable – the material returns to its original shape when the stress is removed. Stresses above the elastic limit cause permanent deformation or fracture

The origins of moduli. Atoms together, some weakly, some strong bind strongly enough they form solids. The stronger the bond, the higher is the modulus of the solid. Think of the bonds as springs (Figure 3). The atoms have an equilibrium spacing; a force pulls them a little, to a new spacing, but when it is released they return back to their original spacing.



Author	Title	Chapter
Callister	"Materials Science and Engineering: an Introduction"	6
Budinski	"Engineering Materials: Properties and Selection"	2
Askeland	"The Science and Engineering of Materials"	6
Shackelford	"Introduction to Materials Science for Engineers"	6
Ashby et al	"Materials: Engineering, Science, Processing, Design"	4, 5



HELP, Video tutorials, ...

The screenshot shows the GRANTA EduPack Help interface. At the top, a software menu bar includes File, Edit, View, Select, Tools, Window, Feature Request, and Help. Below this is a secondary toolbar with icons for Home, Browse, Search, Chart/Select, Solver, Eco Audit, Synthesizer, Learn, Tools, Settings, and Help. A red arrow points from the 'Help' button in this toolbar to the 'Help' section of the main interface. The main interface has a dark header with the 'GRANTA EduPack Help' title and a search bar. A left sidebar lists navigation topics: Welcome, Bienvenue, Willkommen, Bienvenido, 欢迎, New for 2021 R1, Getting started, Browse and Search, Chart and selection stages, Tools, About data, Settings, and Acknowledgements, copyright, and licensing. The main content area features the Ansys logo, the text 'GRANTA EDUPACK', and a welcome message for the 2021 R1 version. It provides an overview of the software's purpose and lists key features: Browse and visualize information, Quickly search for reliable data, Select materials to optimize design, Estimate life cycle environmental impact, Use models to predict properties and costs, and Learn about material properties using science notes and an online glossary. It also mentions that video tutorials and quick start exercises are available. On the right side, a red-bordered box contains a detailed table of contents with links to various help topics, categorized by function: CES EduPack overview Languages, Select, Databases, Browse / Search, Tools, and Installation and Help. Red arrows indicate the flow from the toolbar's Help button to the Help section and then to the detailed table of contents.

File Edit View Select Tools Window Feature Request Help

Home Browse Search Chart/Select Solver Eco Audit Synthesizer Learn Tools Settings Help

GRANTA EduPack Help

Welcome
Bienvenue
Willkommen
Bienvenido
欢迎
New for 2021 R1
Getting started
Browse and Search
Chart and selection stages
Tools
About data
Settings
Acknowledgements, copyright, and licensing
Learn Online

Search

Ansys

GRANTA EDUPACK

Welcome | Bienvenue | Willkommen | Bienvenido | 欢迎

Welcome to the Help for GRANTA EduPack 2021 R1

GRANTA EduPack is designed to support the teaching of materials and processes across all levels of study.

- Browse and visualize information about materials and processes.
- Quickly search for reliable data.
- Select materials and processes to optimize your design.
- Estimate the life cycle environmental impact of a product during early-stage design.
- Use models to predict properties and costs.
- Learn about material properties using science notes and an online glossary.

Video tutorials and Quick start exercises are available to help you quickly get the most out of GRANTA EduPack.

Find out how Keyboard shortcuts and accessibility make GRANTA EduPack easier to use and more accessible to everyone.

CES EduPack overview Languages

- CES EduPack overview [8:13]
- CES EduPack overview in French [8:56]
- CES EduPack overview in Spanish [8:46]
- CES EduPack overview in German [8:43]
- CES EduPack overview in Chinese [8:31]

Select

- How to select materials [2:57]
- Create Charts [5:31]
- Format your Charts [5:37]
- Get the most out of Charts [4:02]
- Limit your material choices [3:34]
- Discover the Tree [2:30]
- Explore and combine stages [3:34]

Databases

- Introductory Elements database [3:01]
- Introductory Architecture database [3:10]
- Introductory and advanced Bioengineering db [4:03]
- Learn more about the advanced Level 3 database [3:50]
- Advanced Aerospace database [2:48]
- Advanced Sustainability database [6:03]
- Advanced Polymer database [3:25]
- Advanced Eco Design database [2:50]

Browse / Search

- How to navigate with Browse (part 1 of 3) [3:17]
- How to navigate with Browse (part 2 of 3) [4:29]
- How to navigate with Browse (part 3 of 3) [3:11]
- Make the most of Advanced Search [3:28]
- How to select materials [2:57]

Tools

- Add your own records [3:18]
- Create your customized Subsets [3:44]
- Personalize your Settings [1:50]
- Discover the Eco Audit tool [7:17]
- Learn more about the Eco Audit Enhanced tool [4:53]
- Explore Hybrid Synthesizer features [4:32]
- Estimate the cost of a part [5:00]

Installation and Help

- Installation and support(part 1 of 2) [3:10]
- Installation and support(part 2 of 2) [2:02]
- Find all answers at Help Online [2:42]
- Explore Learn Online [2:20]

Task 0

Pre-assignment / mini task

Instructions: Check the following questions and exercises. Access the course textbook and read chapters 1 (4th edition available in the Aalto Library as an e-book).

Task 0_0: Check GRANTA EduPack software and learn the user interface, watch tutorial videos and follow the exercises by yourself (In GRANTA EduPack 2023 R2 go to → Help/Video Tutorials → “GRANTA EduPack overview”, and “Select” videos).

Task 0_1: You will be given the following material groups to study and choose one as you wish:

Composites	Plastics
Foams	Non-technical ceramics
Metals	Technical ceramics
Elastomers	Natural materials

- Explain the description of given material group (what it is, what are the typical material in the group, etc.)
- Give three examples of specific materials representative of this group and corresponding examples of what they are used for.

Task 0_2: From the GRANTA EduPack-database, find the following material properties:

Fracture toughness	Flammability
Transparency	Maximum operating Temperature
Specific heat capacity	CO ₂ footprint
Thermal conductivity	Coefficient of thermal expansion
Electrical conductivity	Toxicity

- What do they mean and how they can be measured/evaluated? (Use short discussion with terms, charts, etc.)
- Find typical values for the material group given in Task 0_1. Choose 4 material properties and compare these properties in Level 2 and Level 3 (see the tutorials to understand the meaning of “levels”). Shortly discuss what are the differences in the results.

Task 0_3. Find translations of the material properties in the list in Task 0_2 in at least two languages that are not English. Use your native language if that is not English, and at least one additional language you consider important in technology/engineering.

Summary

- **Classification** lets materials data be **organized** and **retrieved**
- Data take two broad forms:
 - (a) **Numeric, non-numeric data** that can be **structured**
 - (b) **Documentation**, usually in the form of text, graphs and images
- **GRANTA EduPack** allows access to data via

Browse

 or

Search
- **Underlying science** provided via
 - **Science notes** linked to material property names
 - **Video tutorials** accessed via

Help
 - **References** to leading texts