UNIVERSITY OF CAMBRIDGE

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GRANTA CES 2008 EDUPACK

CDIO Workshop

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Granta Design

www.grantadesign.com/education/

Agenda

- **Overview of CES EduPack 2008** (10 mins)
- **Scenario-based hands-on session** (25 mins)
- **Links to more advanced resources** (5 mins)
- **Wrap up** (5 mins)

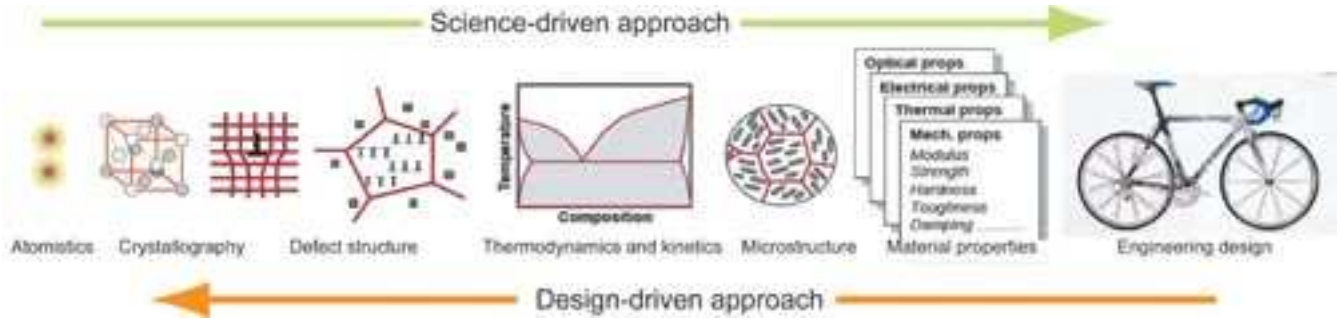
Introducing the CES EduPack

- **CES EduPack 2008** is a supporting resource for teaching materials in engineering, science, processing and design

- **Widely used**: 600+ universities and colleges and 1,500+ departments.

- **Adaptable**, with exceptional depth and breath, making it extremely useful to many departments. Many of the worlds leading universities now use it as a **campus-wide resource.**

Approaches to materials teaching



- The **CES EduPack** complements teaching, regardless of the approach or text adopted
- Used in courses that take **science-based approach** using texts such as

  Callister, Budinski, Askland etc
- Used in courses that take **design-based approach** using texts such as

  Dieter, Ashby and Jones etc
- Used in **project/scenario-based teaching** for materials and manufacturing processes
- Used for **distance learning** and to encourage **self- teaching** – students have copy on their own portable

CES EduPack 2008

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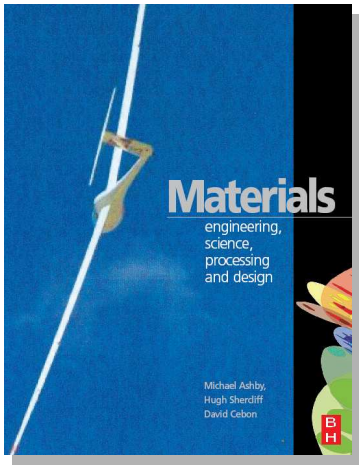
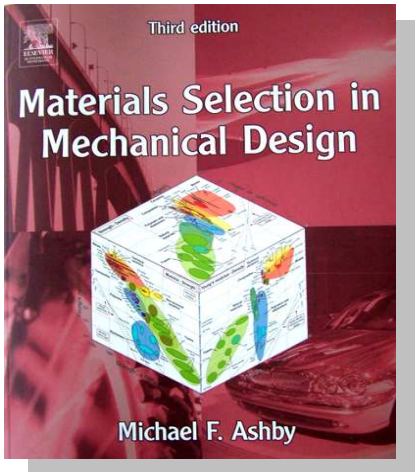
❑ Software

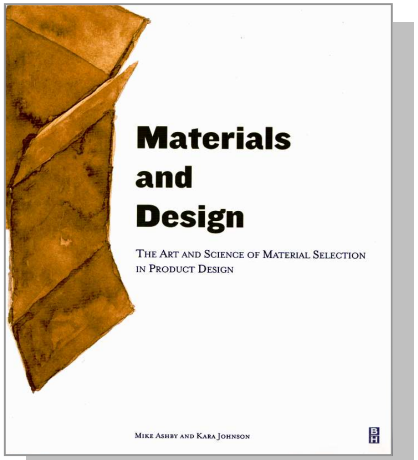
❑ Introductory text



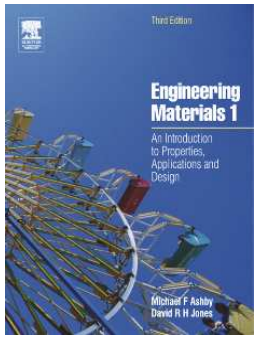
❑ Advanced text

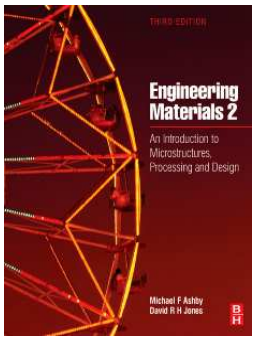


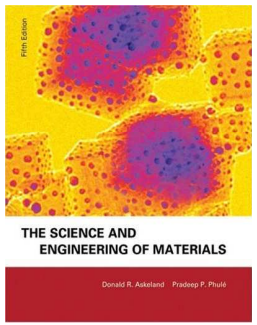
❑ Industrial design text

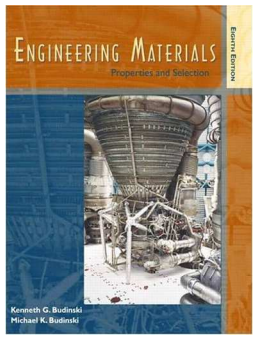


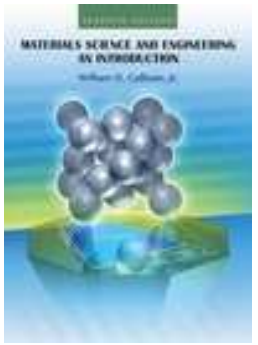
+ links to other materials texts

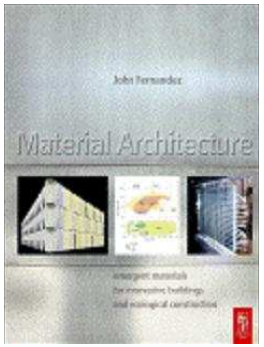












The 3 levels of the CES EduPack software

The CES EduPack

Periodic table

- **The science**
- **Records for 111 elements**

Level 1

- **1st year** students: Engineering, Materials Science, Design

64 materials, **75** processes

Level 2

- **2nd - 4th year** students: Engineering and Materials Science and Design.

94 materials, **107** processes

Level 3

- **3rd - 4th year**, **masters** and **research** students: Engineering Materials and Design.

3,300 materials, **250** processes

Materials science

Bio engineering

Design for the environment

Aeronautical engineering

Architecture & civil eng

MORE

Teaching materials to 1st and 2nd years

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The challenge

- To engage and hold interest in **materials** at the start of engineering and design courses

The starting point

- Engineers and designers make things. They make them out of **materials,** using **processes.**

- What do you need to know to do this successfully?
  - A **perspective** of the world of materials and processes
  - An **understanding** material properties and their origins
  - An ability to **select** those that best meet **requirements of a design**
  - Access to **information** and **tools** for comparison and selection

Finding information

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File Edit View Select Tools

Toolbar → **Browse** | Select | **Search** | Print | Search web

Table: ***MaterialUniverse***

Subset: ***Edu Level 1***

- **MaterialUniverse**
  - **Ceramics and glasses**
  - **Hybrids: composites etc**
  - **Metals and alloys**
  - **Polymers and elastomers**

Find what ***Lexan***

Look in table ***Materials***

Polycarbonate (PC)

The material

PC is one of the 'engineering' thermoplastics, meaning that they have better mechanical properties than the cheaper 'commodity' polymers. The family includes the plastics polyamide (PA), polyoxymethylene (POM) and polytetrafluorethylene (PTFE). The benzene ring and the -OCOO- carbonate group combine in pure PC to give it its unique characteristics of optical transparency and good toughness and rigidity, even at relatively high temperatures.

General properties

Density	**1140**	**-1210**	**kg/m^3**
Price	**3.6**	**- 4.47**	**USD/kg**

Mechanical properties

Young's modulus	**2**	**- 2.44**	**GPa**
Yield strength (elastic limit)	**59**	**- 70**	**MPa**
Tensile strength	**60**	**- 72.4**	**MPa**
Elongation	**70**	**- 150**	**%**
Hardness - Vickers	**17.7**	**- 21.7**	**HV**
Fatigue strength	**22**	**- 30.**	**MPa**
Fracture toughness	**2.1**	**- 4.60**	**MPa.m^1/2**
Mechanical loss coefficient	**0.01**	**- 0.018**	

Thermal properties

Thermal conductivity	0.18	- 0.21	W/m.K
Specific heat	1535	- 1634	J/kg.K
Thermal expansion	120	- 136	µstrain/°C

Typical uses

Safety shields and goggles; lenses; glazing panels; business machine housing; instrument casings; lighting fittings; safety helmets; electrical switchgear; laminated sheet for bullet-proof glazing; twin-walled sheets for glazing; kitchenware and tableware; microwave cookware, medical (sterilizable) components.

Tradenames

Calibre, FR-PC, Latilon, Lexan, Lupilon, Makrolon, Naxell, Nyloy, Panlite, Sinvet, Star-C. Starglas. Triex. Xantar

Understanding: the underlying science

Age-hardening wrought Al-alloys

Description. The high-strength alum
alloys rely on age-hardening: a sequenc
heat treatment steps that causes the
precipitation of a nano-scale dispersion
intermetallics that impede dislocation m
and impart strength.

General properties
- Density
- Price

Mechanical properties
- Young's modulus
- Yield strength (elastic limit)
- Tensile strength
- Elongation
- Fatigue strength at 10^7 cycles
- Fracture toughness

Thermal properties
- Melting point
- Maximum service temperature
- Thermal conductivity
- Thermal expansion coefficient

Electrical properties
- Electrical resistivity

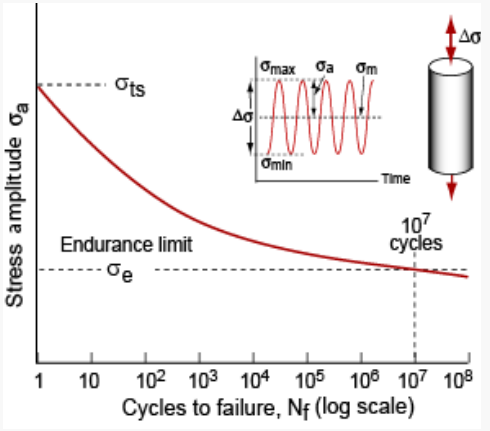
Young's modulus

Ductile metals — Tensile strength σ_y

Fatigue strength at 10^7 cycles

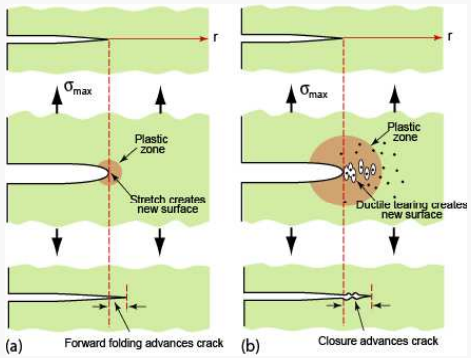
Definitions and measurement.

Material subjected to repeated stress cycles may fail even when the peak stress is well below the tensile strength, or even below that for yield. Fatigue data are measured and presented as curves, where $\Delta\sigma$ is the range over which the stress varies and N_f is the number of cycles to failure.....

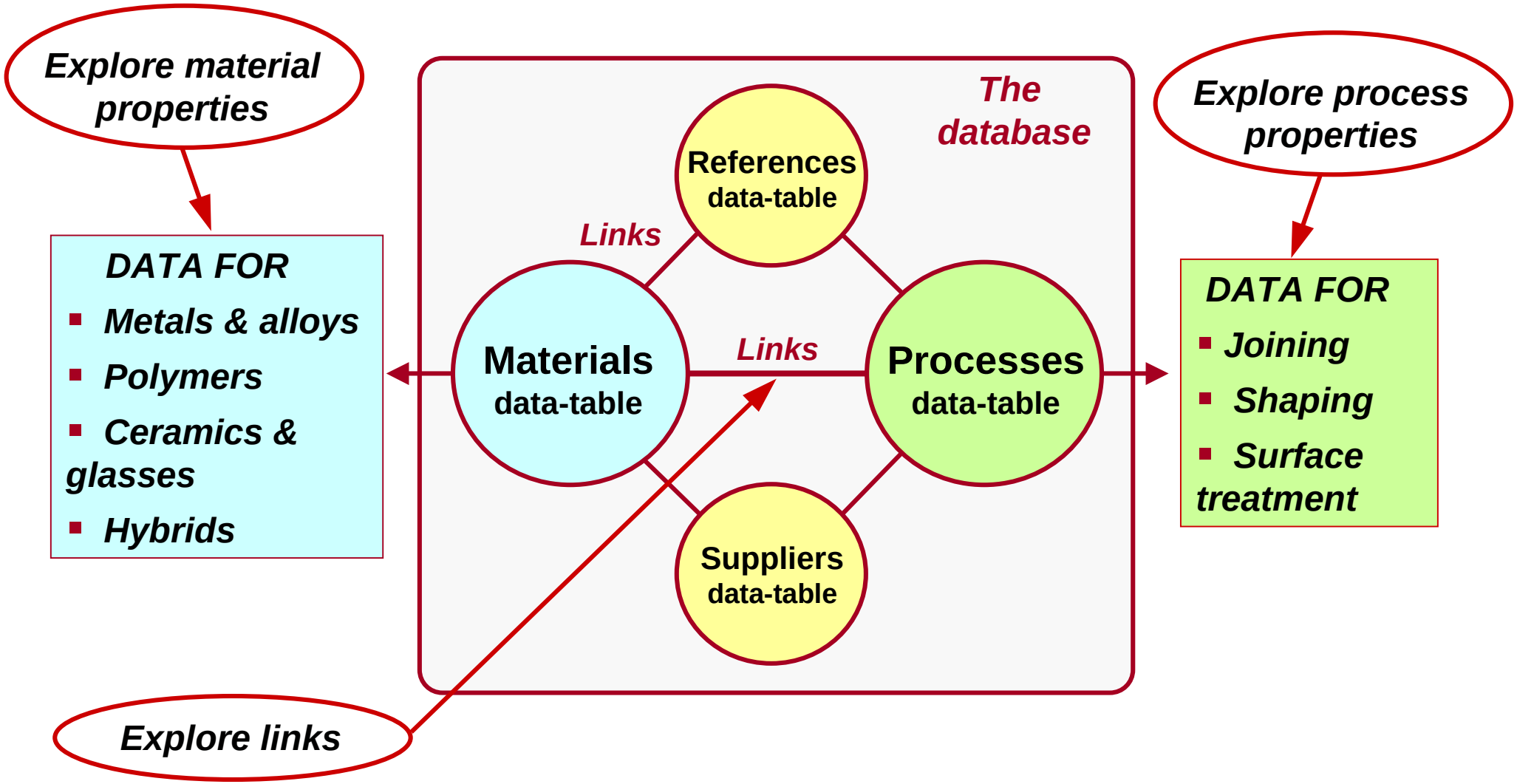


How do fatigue cracks propagate?

Holes, change of section, cracks, and surface scratches concentrate stress so that, even when the sample as a whole remains elastic (the "high-cycle" regime), local plasticity occurs. The damage this creates accumulates, finally developing into a tiny crack. The crack propagates in the way shown on the left of Figure 2. .....



Structure of levels 1 & 2



Creating charts

File Edit View Select Tools

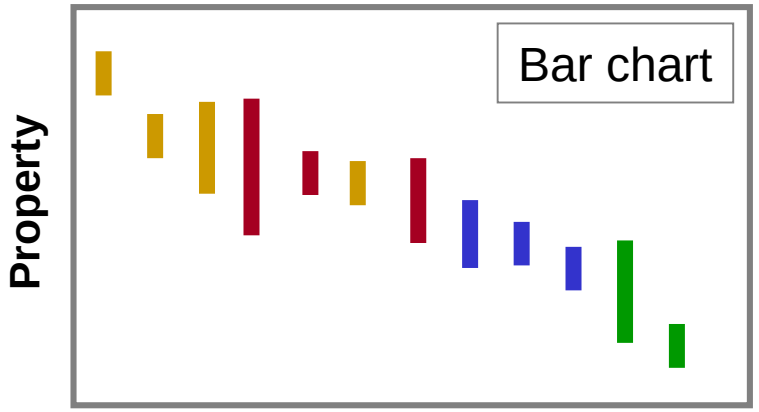
Toolbar → Browse | Select | Search | Print | Search web

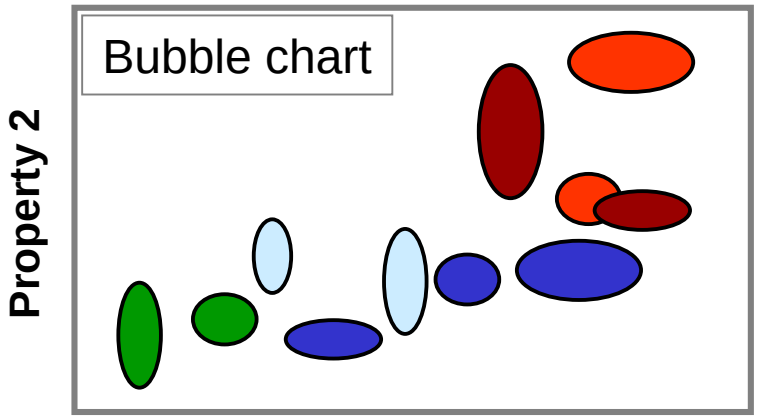
1. Selection data

Edu Level 2: Materials

2. Selection Stages

Graph | Limit | Tree





Perspective: mechanical properties

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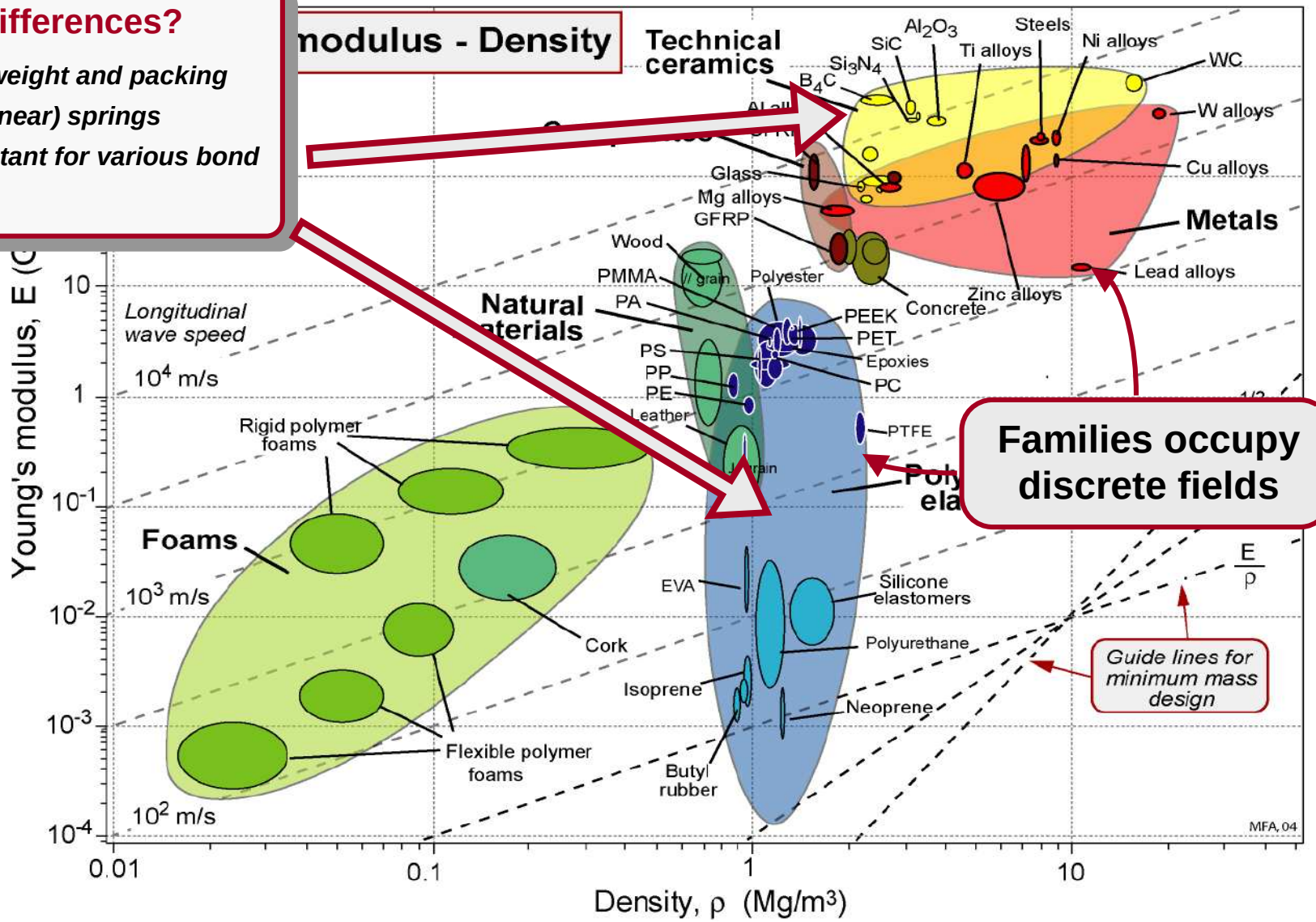
Why the differences?

- *Atom size, weight and packing*
- *Bonds as (linear) springs*
- *Spring constant for various bond types.*



Families occupy discrete fields

Ability to select

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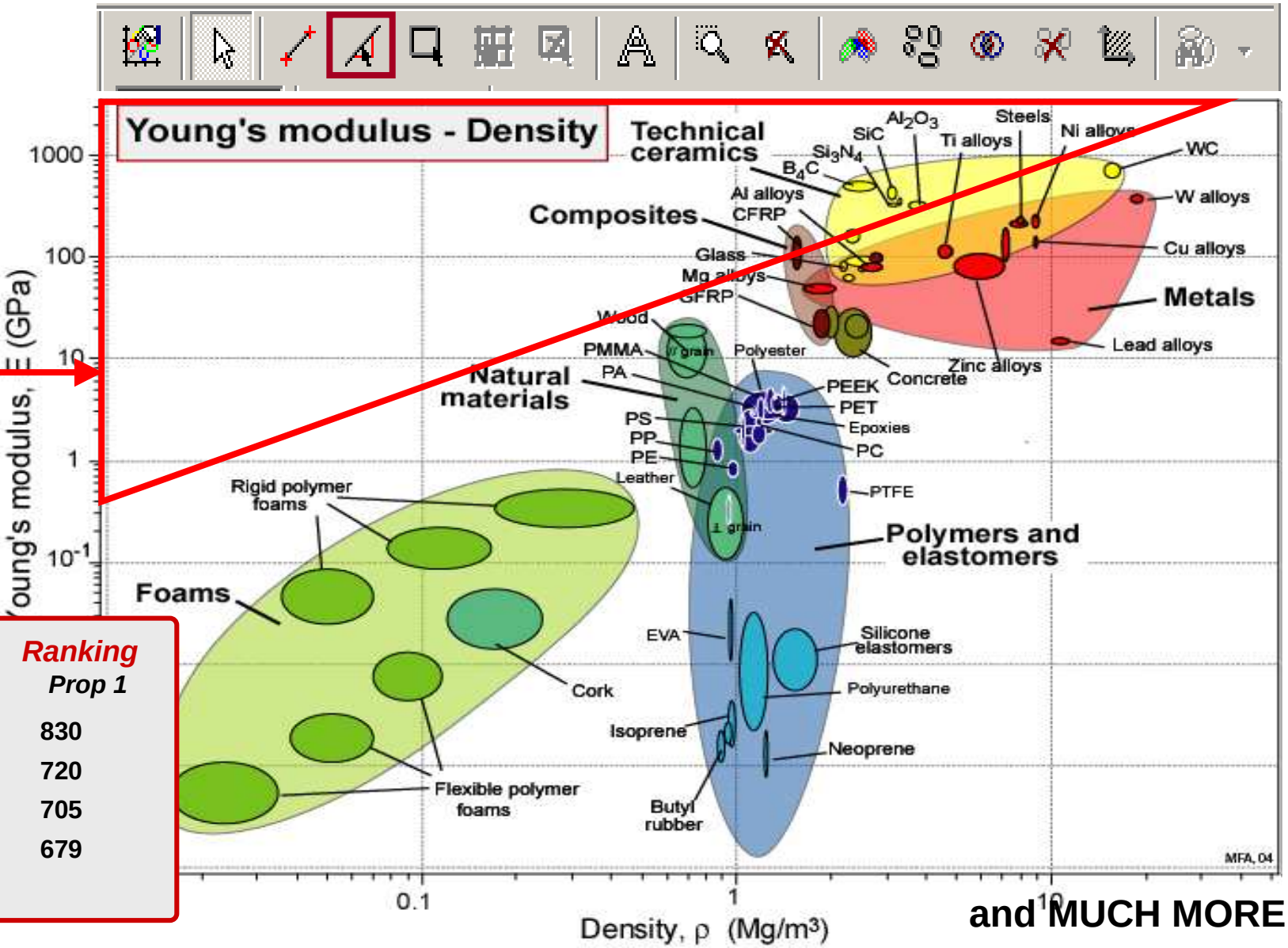
Stiff and light

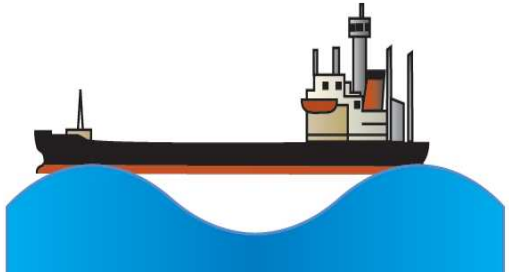


Results	*Ranking*
X pass	*Prop 1*
Material 1	830
Material 2	720
Material 3	705
Material 4	679
etc...	

and MUCH MORE

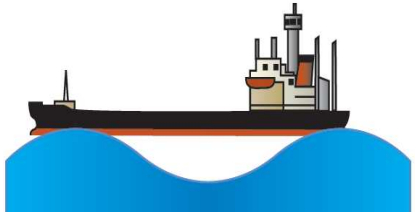
Hands-on session

Scenario 1 - Exploring materials for the hull of a boat/ship.

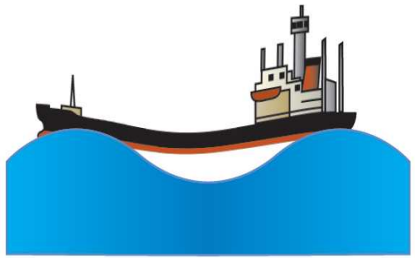


Scenario 2 - Redesigning the CD case.

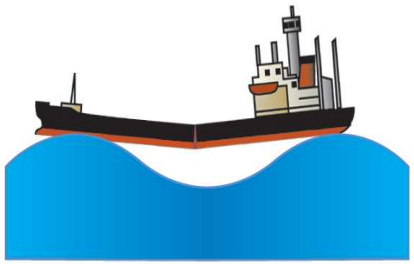
More detail scenario 1: Merchant ship hull



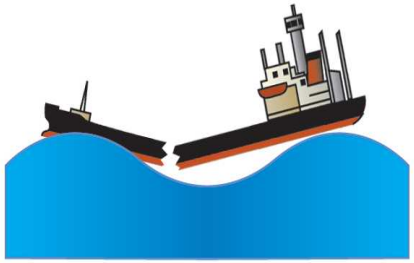
← Stiff
Strong
Tough
} All OK !



← Not stiff enough (need bigger E)



← Not strong enough (need bigger σ_y)



← Not tough enough (need bigger K_{ic})

Accessing level 3

Over **3,000 material records** covering virtually all purchasable engineering materials each with more than fifty general, mechanical, thermal, optical, electrical, and corrosion properties.

Comprehensive

- All material families covered
- The result of over 60 man years work

Universal & Comparable Properties

- Universal - properties are valid for all records
- Comparable - All data in the same format (e.g. Hardness)

Complete Data

- No holes in data to prevent elimination due to lack of data
- Estimating techniques used to fill holes (but highlighted)

Specialist CES EduPack 2008 Editions

Design, Mechanical & Manufacturing	**The Standard Edition with 3 levels *(3,300 materials & 250 processes)***
Materials science	**+ Elements *(crystallographic, mechanical, thermal, and electrical properties of elements across the Periodic Table)***
Polymer engineering	**+ CAMPUS, ChemRes, MoldFlow, IDES *(50,000 polymers)***
Aerospace Motor sport	**+ MMPDS & Mil Handbook 17 *(US Aerospace approved alloys and composites)***
Architecture & Civil engineering	**+ Architecture and Structural sections *(construction materials and shaped sections)***
Environmental engineering	**+ Eco Design data *(Geo-economic, production, processing, recycling)***
Bio Engineering	**+ Natural & Bio Materials data**

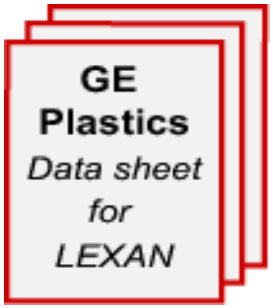
Documentation: the pedigree

Documentation: *"now that the number of candidates is small, explore their character in depth"*

Handbooks

Trade associations

Suppliers' data sheets



Material portals

Documentation:
the "pedigree" of surviving candidates

Wrap up

- **Strong initial introduction to materials and manufacturing processes:** simplicity and visual impact makes Level 1 easy to use with 1st and 2nd year teaching
- **Strong links with design:** good fit with project work and problem-based learning. Level 3 suitable for final-year "capstone" design courses, Material data can be exported to CAD and FE programs
- **Motivation:** students like it – helps re-invigorate the teaching of materials and manufacturing processes to engineering students
- **Immediate integration** with other engineering subjects and links to other high pedigree teaching/materials resources
- **Self-teaching** enabled when each student has a copy of the software