



## Physical Bases of Dental Material Science

### 8.

#### Mechanical properties of materials 2.

##### Plasticity

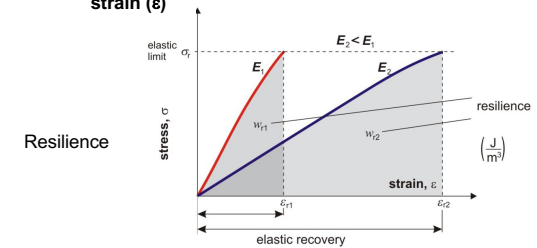
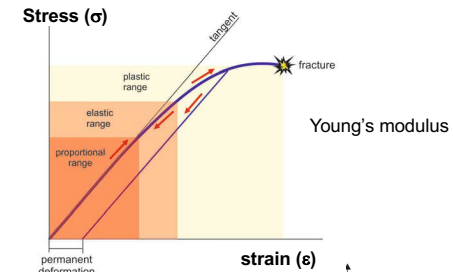
Kiemelt témák:

- ❖ *Strength*, plasticity and toughness
- ❖ Mechanism of plastic deformation in crystals
- ❖ Fractures
- ❖ Hardness

E-book  
chapter 16, 17.

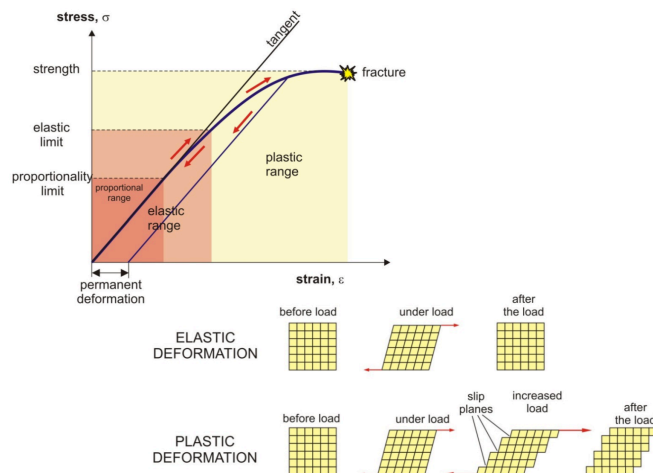
Problems:  
Chapter 4.:  
26, 27, 29, 30, 32,  
33, 34, 36

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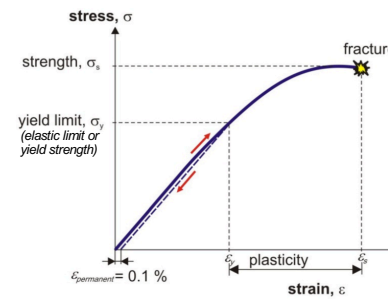
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## Stress - strain diagram



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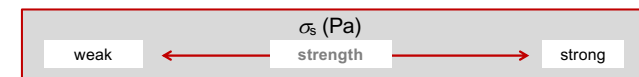
## Plastic behavior



yield limit,  $\sigma_y$  (Pa)

strength,  $\sigma_s$  (Pa) • tensile,  
• compressive,  
• bending,  
• shear,  
• torsional

plasticity,  $\epsilon_s - \epsilon_y$  (%)

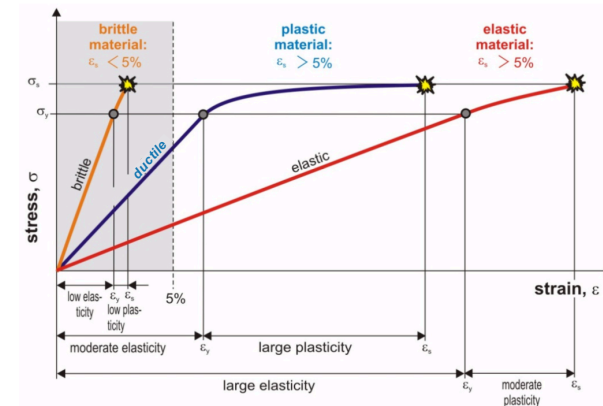


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## Strength of some dental materials

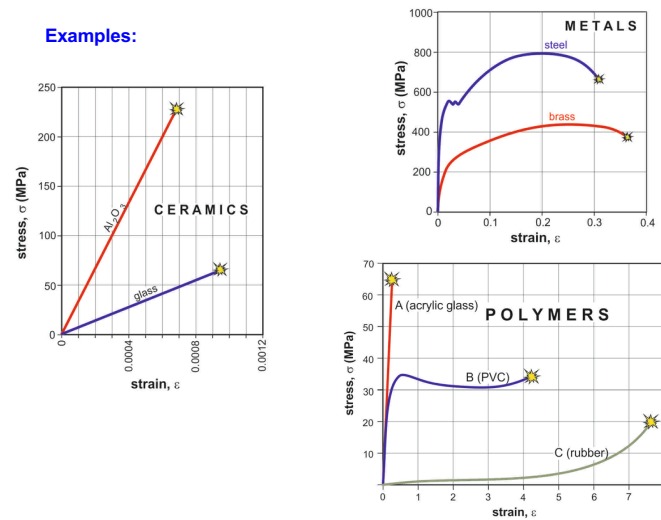
material	$\sigma_{\text{tensile}}$ (MPa)	$\sigma_{\text{comp.}}$ (MPa)
enamel	$\approx 10$	$\approx 400$
dentine	$\approx 110$	$\approx 300$
ceramics	5-400	20-5000
porcelain	$\approx 25$	$\approx 300$
polyethylene (high density)	$\approx 30$	
amalgam	30-55	200-450
PMMA	$\approx 50$	$\approx 80$
glass	$\approx 50-70$	$\approx 700$
gold	108	
aluminum oxide	$\approx 170$	$\approx 2100$
zirconium dioxide	$\approx 250$	$\approx 2500$
gold alloys	300-900	
Pd-Ag alloys	400-700	
Ni-Cr alloys	400-900	
Co-Cr alloys	600-800	
Ti alloys	900-1100	
carbon-fiber (61%)	$\approx 1700$	
reinforced epoxy		

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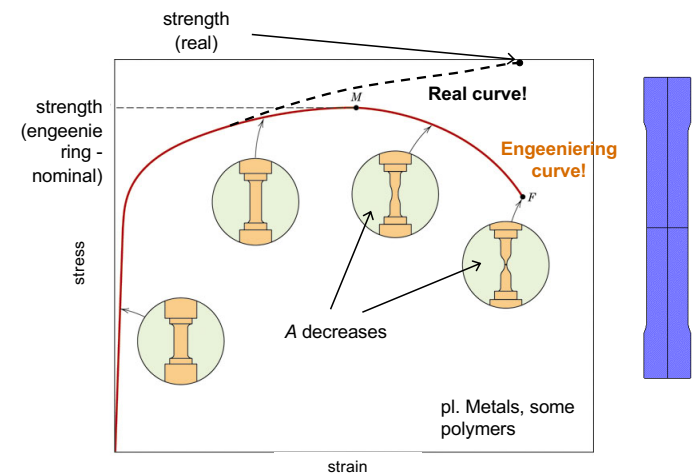
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## Examples:



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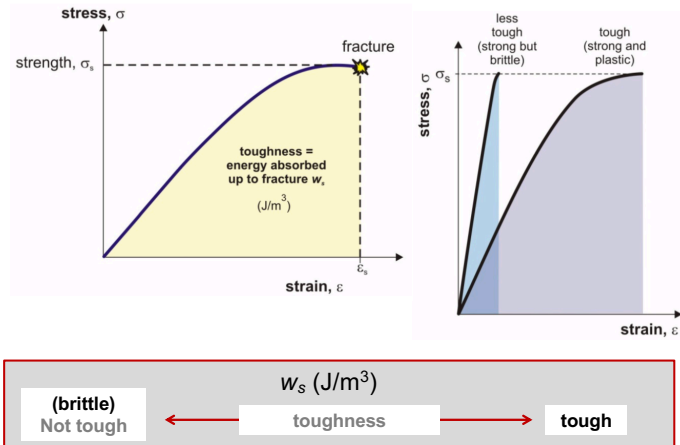
## Engineering vs. „real” system



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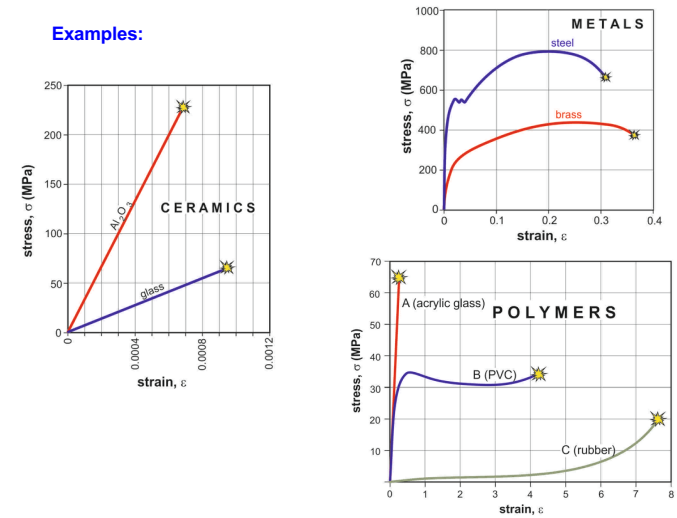
# Toughness

vagy energy absorbed until fracture ( $w_s$ )

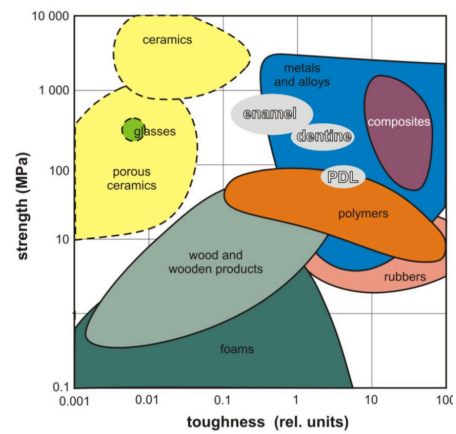


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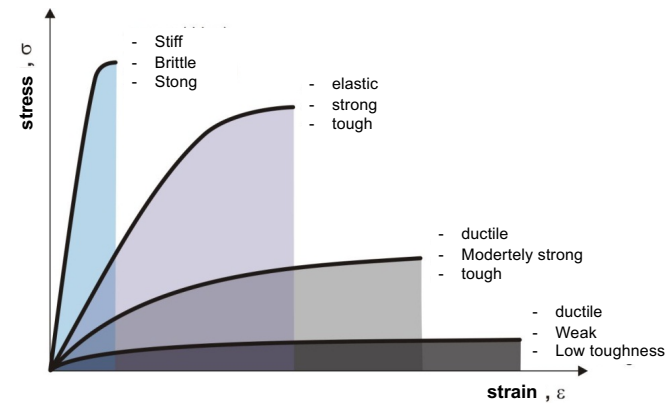
## Examples:



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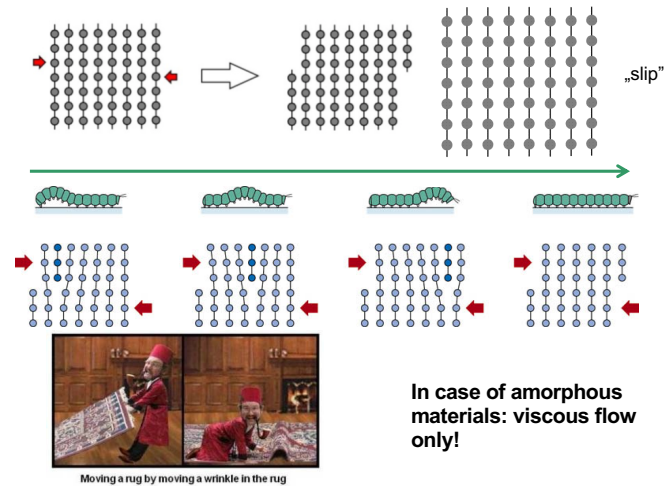


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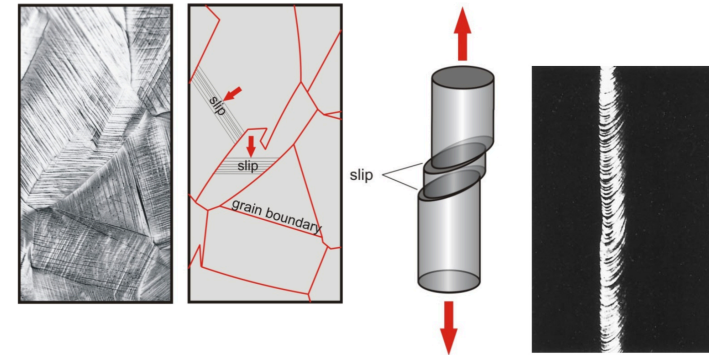
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### Mechanism of plastic deformation in crystals:

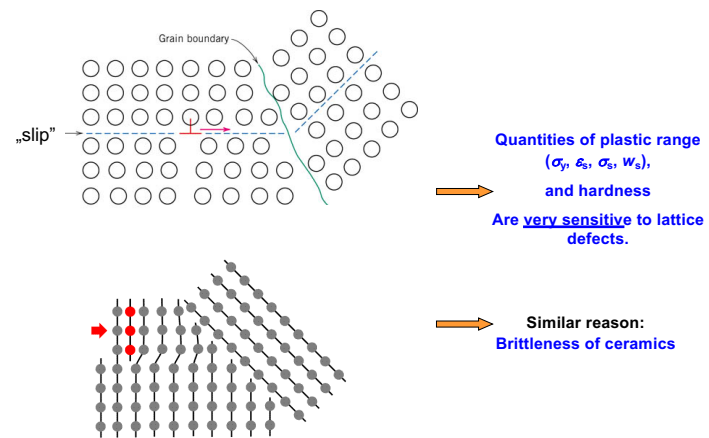


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### Movement of dislocations

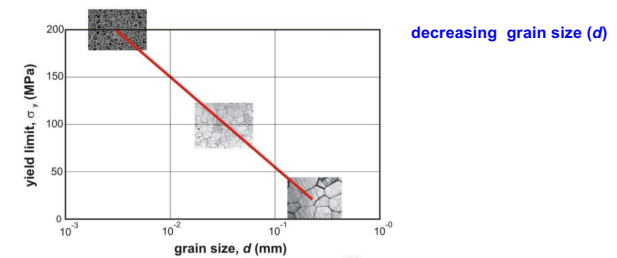


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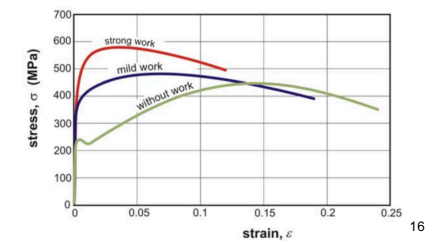


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### Changing the strength and plastic properties of metals



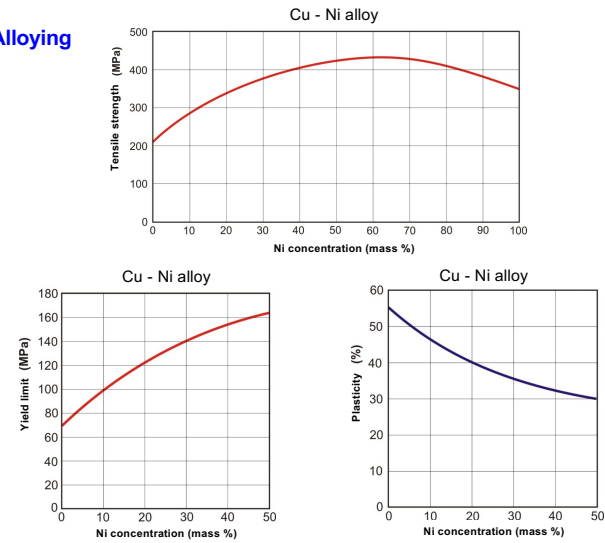
### Cold-work



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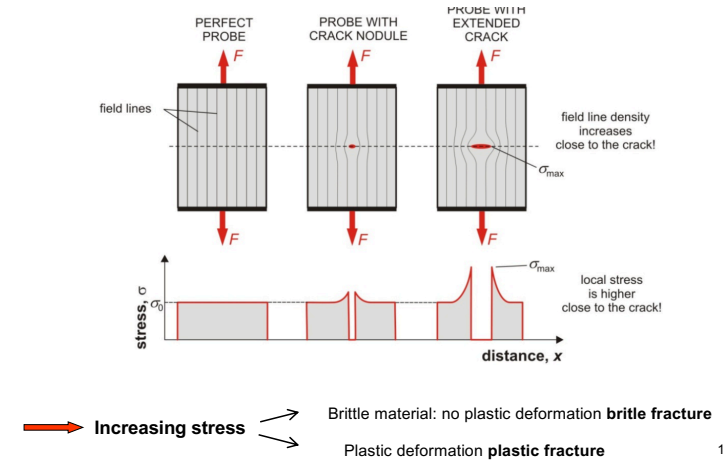
## Alloying



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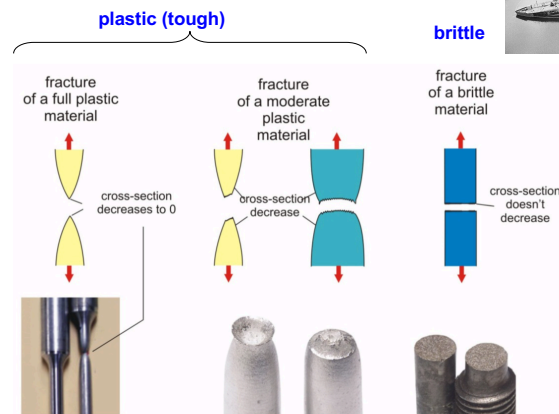
## Fracture

Mechanism:



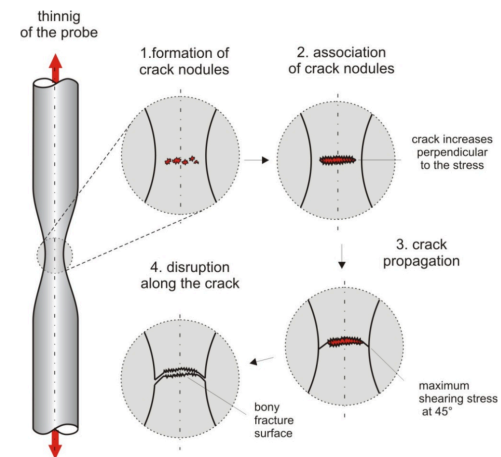
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## Fracture types



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## Phases of fracture in a ductile material



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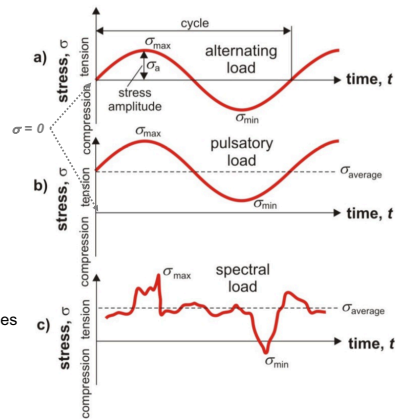
## Fatigue, fatigue fracture



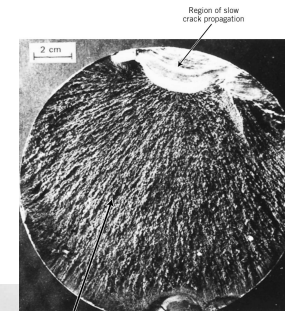
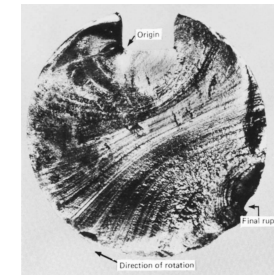
Persistent, repetitive load (stress)  
→ structural changes  
→ strength decreases

**Crack formation!**

Types of loads:

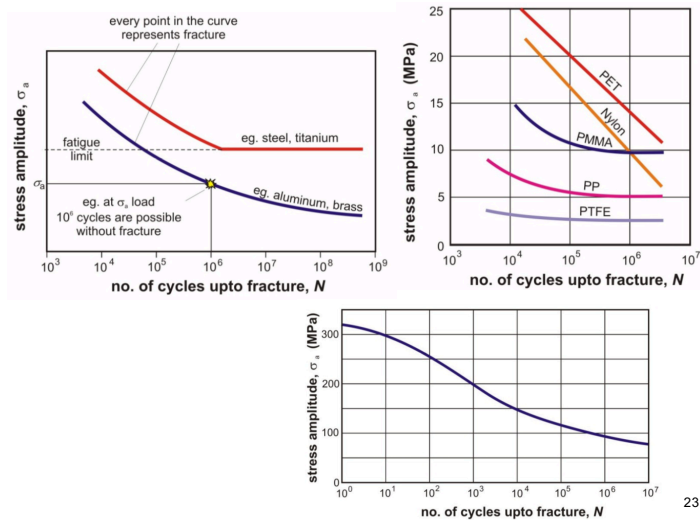


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Fatigue curve:



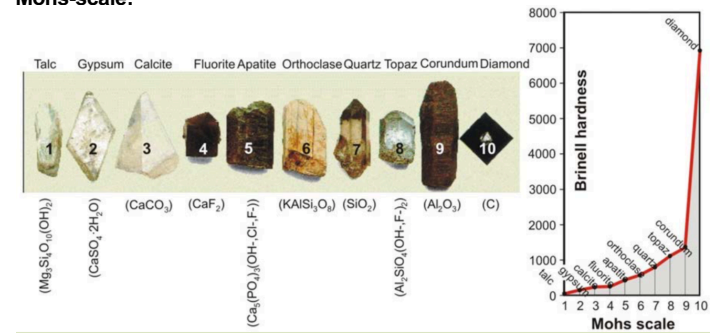
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## Hardness

Resistance against plastic deformation



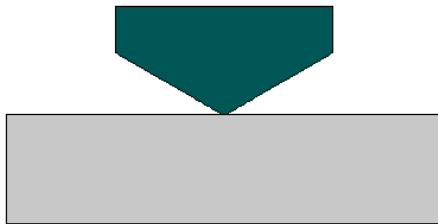
Mohs-scale:



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## Hardness measurement

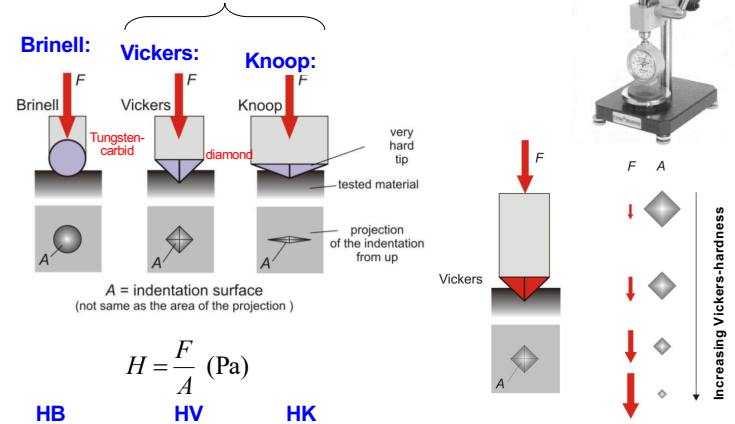
Rockwell C Test 4940 Sy=193 ksi u=.2  
time= 0.0000E+00  
dst= 0.10000E+01



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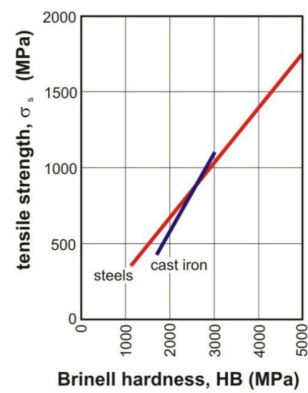
## Hardness measurement

Methods of microhardness measurement



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### Connections with strength:

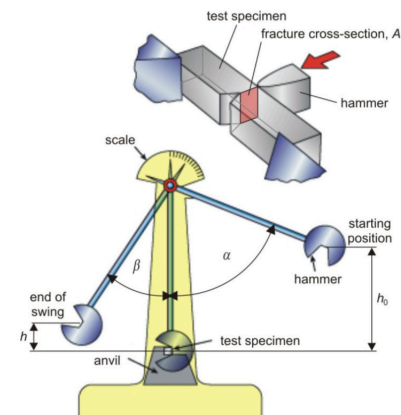


### Hardness of dental materials:

material	HV (MPa)	HK (MPa)
dentine	≈ 600	≈ 700
enamel	≈ 3400	3400-4000
gold		60-70
acrylate	≈ 200	≈ 200
gold alloys	600-2500	≈ 2000
amalgam	≈ 1000	
Pd-Ag alloys	1400-1900	
Ni-Cr alloys	3000-4000	2000-3500
Co-Cr alloys	≈ 4000	3000-4500
glass		≈ 5000
porcelain	4500-7000	≈ 6000

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## Charpy test

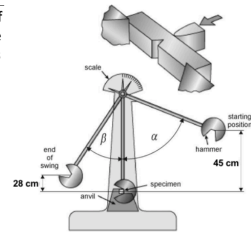


**Impact energy** = The loss of the hammer's potential energy (J)

**Specific impact energy** = impact energy / cross sectional area of test specimen ( $\text{J/m}^2$ )

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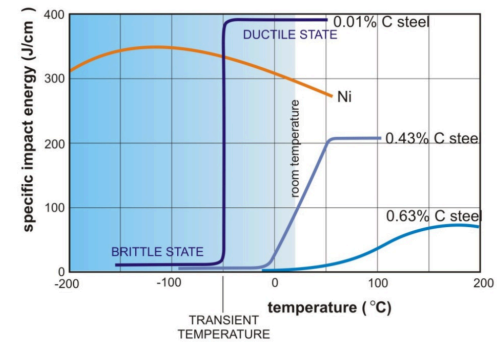
5. A piece of zirconia with a fracture cross-sectional area of  $1 \text{ cm}^2$  is tested in a Charpy. The drawing shows the hammer's start and end positions. The hammer has a mass of 2 kg. Calculate the specific impact energy of zirconia!



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Effect of temperature:

plastic fracture— brittle fracture transition



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