# Consultation days

It can be found on the web page.

The consultation starts: 14 p.m.

Topic list and formula book may be found on the webpage.
There is an e-book in pdf format, too.

(biofiz.semmelweis.hu – English/Education/dentistry – Documents page)



Test examples

The pressure inside of a 0.1 m$^3$ oxygen gas container is $3*10^5$ Pa at 20 °C temperatures. How many moles of oxygen are in the container?

Crystallization, parameters acting on the crystal growth.

What is the shear modulus?

Draw a typical fatigue S-N curve!

Give the definition of the next parameters or phenomena:

a./ crystal lattice
b./ ionization energy
c./ Schottky defect
d./ liquidus curve
e./ eutectic point



# Physical base of Orthodontics

Physical basis of dental material science
14.



## Orthodontics

before



after

## Physiological forces in the mouth

**Mastication:**

Large, and short:

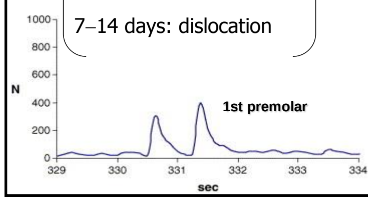
***F* = 100–800 N**

***t* ≤ 1 s**

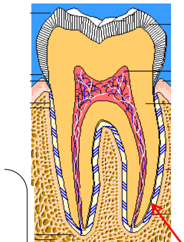
3–5 s: pain

≈ hour: lesion

7–14 days: dislocation







**forces „in rest”:**

small, „constant”:

***F* = 1–10 cN**

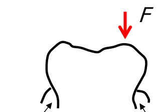
**„active” stabilization (PDL)**

periodontal ligament



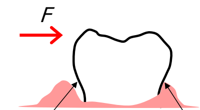
## Instability and motion

„permanent” force (> 10 cN):





$\sum M \neq 0$





pull | load

„unstable” tooth tipping

pull | load

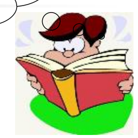
(calcification) | (decalcification)

dislocation (≡ remodeling)



## Motions

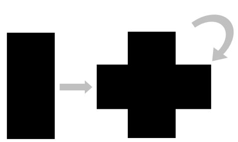
- translation
- rotation
- compound



**translation**

**rotation**

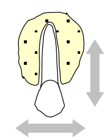
**compound motion** **= translation + rotation**





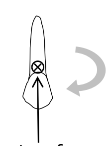
## Motility of the tooth

**translation**



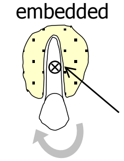
**rotation**

free



center of mass

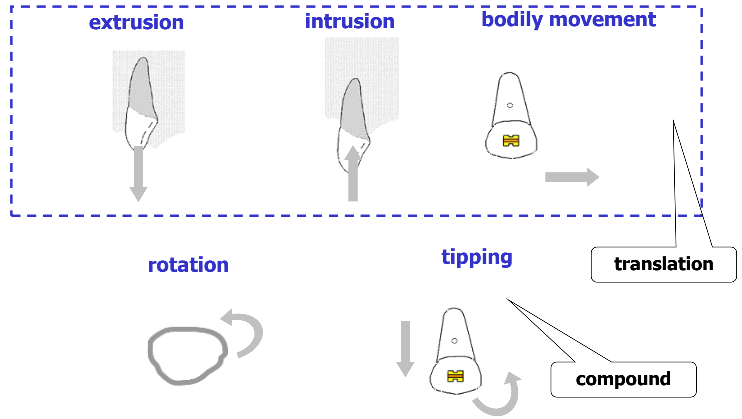
embedded



**center of rotation**

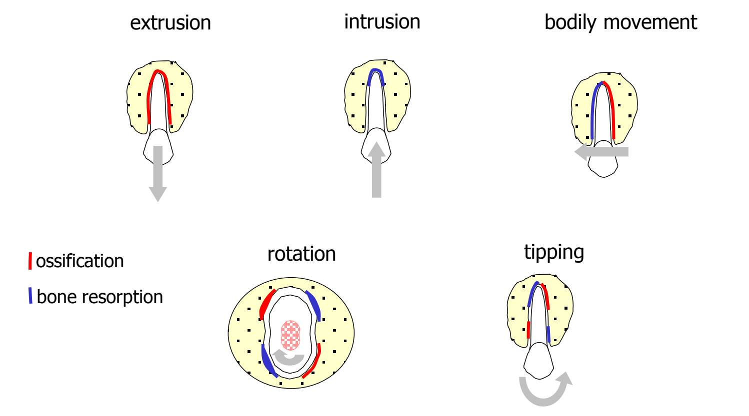
(center of resistance - CR)

## Movements of teeth



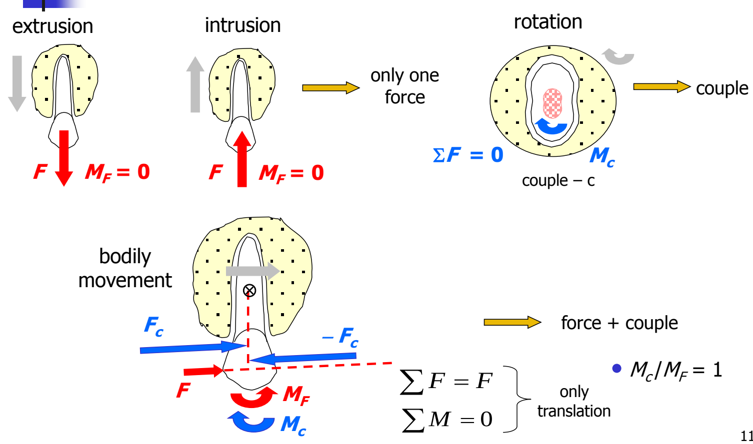



## Mechanism of the movement






## Forces and torques

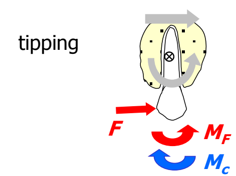



force + couple

$$\sum F = F, \quad \sum M = 0$$ only translation

- $M_c / M_F = 1$

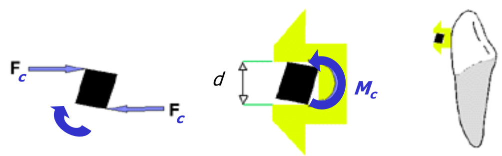





| force | couple | $\sum F$ | $\sum M$ | |
|---|---|---|---|---|
| – | ✓ | 0 | $M_c$ | → rotation |
| ✓ | – | $F$ | $M_F$ | → **tipping** translation + rotation ($M_c = 0$) |
| ✓ | ✓ | $F$ | $M_F - M_c$ | → **controlled tipping** translation + rotation |

- $0 < M_F - M_c$ ($M_c / M_F < 1$)
- $M_F - M_c < 0$ ($1 < M_c / M_F$)

## Realization of a couple




- torsion

$$M = G\frac{r^4\pi}{2l}\phi$$



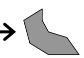
## Orthodontic brace

An elastic object, that stores the mechanical energy and exerts a force on teeth, („**mechanical accumulator**”).

*before application:*

deformation

$F$

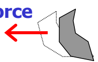


energy intake

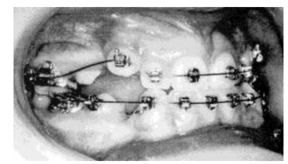
*under application:*

**restoring force**

$F$



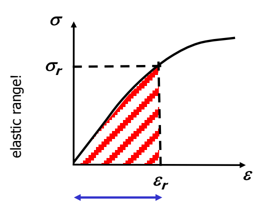
utilization of the stored energy





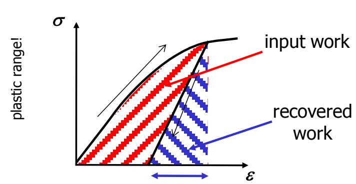
## Mechanical properties of the brace

- material properties: stiffness, elastic strain recovery, resilience




**resilience** = $\frac{1}{2}\sigma_r \cdot \varepsilon_r = \frac{1}{2}E\varepsilon_r^2$

input work = recovered work,
if there is no friction!!!




examples:
- plastics
- steel
- cobalt-chrome alloys
- titanium alloys



- geometrics: shape, size (e.g. thickness, length, ...)
  - stretching/compression $F = E\frac{A}{l}\Delta l$ $W = \frac{1}{2}E\cdot\frac{A}{l}\Delta l^2$
  - bending $F = 3E\cdot\frac{\Theta}{l^3}\cdot s$ $W = \frac{1}{2}3E\cdot\frac{\Theta}{l^3}\cdot s^2$
  - torsion $M = G\frac{r^4\pi}{2l}\phi$

Stiffness of the body
spring stiffness

**Problems:**

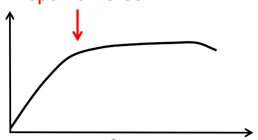
- friction

Friction force ($F_f$):

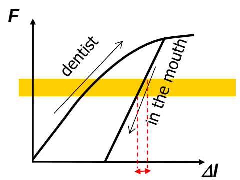
$$F_f = \mu \cdot F_p$$

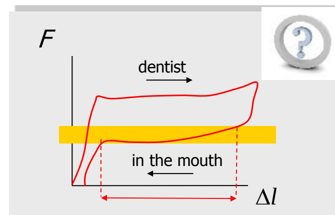
## Restoring force

- amplitude?




- stability?



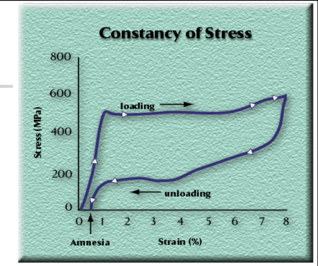


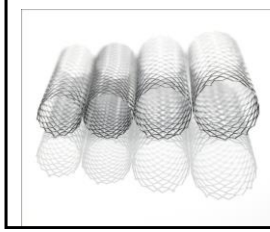

## Superelasticity

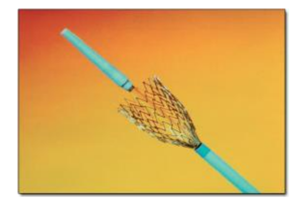
Ni+Ti Cu+Al+Zn Cu+Al+Ni

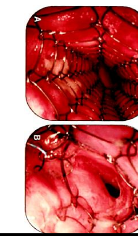
**Nitinol** (**Ni**ckel-**Ti**tanium **N**aval **O**rdnance **L**aboratory)

- superelastic (pseudoelastic)
- It has shape memory
- biomechanical compatibility
- biocompatible







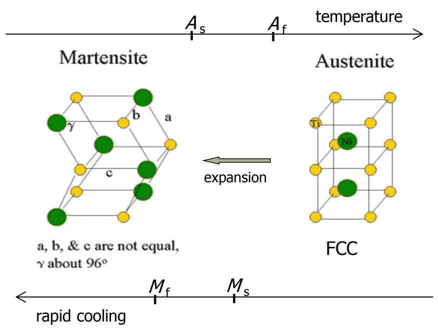


## Superelasticity

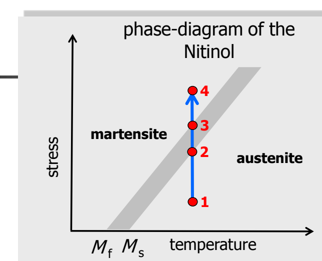
elastic (reversible) response to an applied stress, caused by a phase transformation between the austenitic and martensitic phases of a crystal.

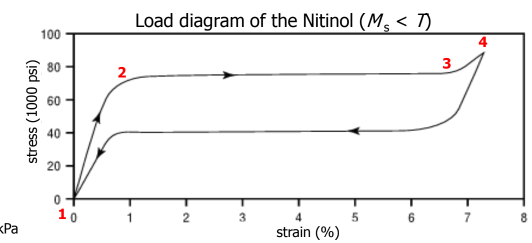
$M_s$-martensite start temperature
$M_f$-martensite finish temperature
(totally martensite)

$A_s$- austenite start temperature
$A_f$- austenite finish temperature
(totally austenite)



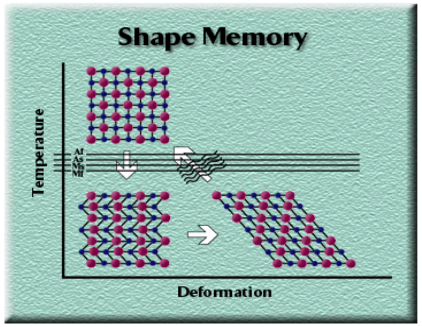



1 psi ≈ 8 kPa

## Shape memory




- **one-way**
  below $A_s$: change the shape after heating shape changes to its original.
- **two-way**
  the material remembers two different shape: at low and at high temperature.

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## Artificial „muscle”

FLEXINOL®
Actuator Wire

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## Selection

**Aspects of selection:**

- good mechanical properties
- tissue compatible
- acid-proof
- non allergic
- cheap

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