Principios de analise 1:

Macro-experimental

(em Ingles: 'heat and beat')

Modelos de continuum-

stress vs strain,

fluxos de calor e ions,

campos electricos e magneticos

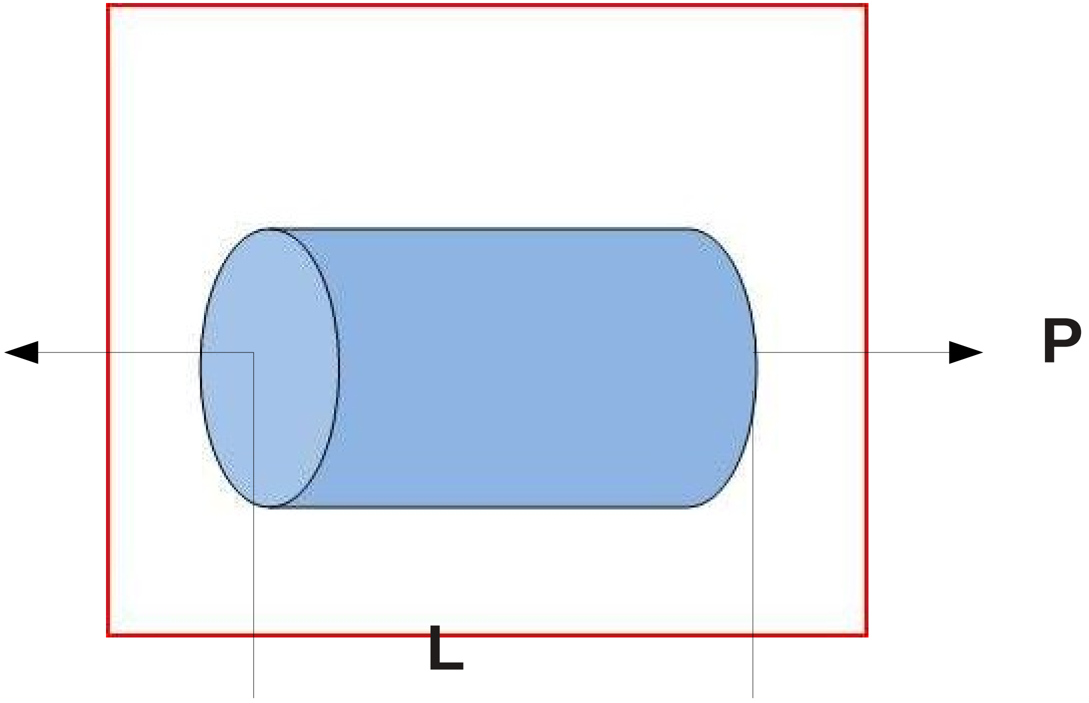
Stress-Strain Relations-
apply a force, measure the deformation

Medieval Model

Modern Model

A basic ingredient in the study of the mechanics of deformable bodies is the resistive properties of materials. These properties relate the stresses (push/pull/shear/twist) to the strains (deformations).

In the tensile test, a load is applied along the longitudinal axis of a circular test specimen. The applied load and the resulting elongation of the member are measured, until the specimen breaks.



Load-deformation data obtained from tensile and/or compressive tests depend on the specimen geometry. However, loads and deformations may be converted to size-independent stresses and strains. Thus $\sigma = P/A$ $\varepsilon = \delta/L$

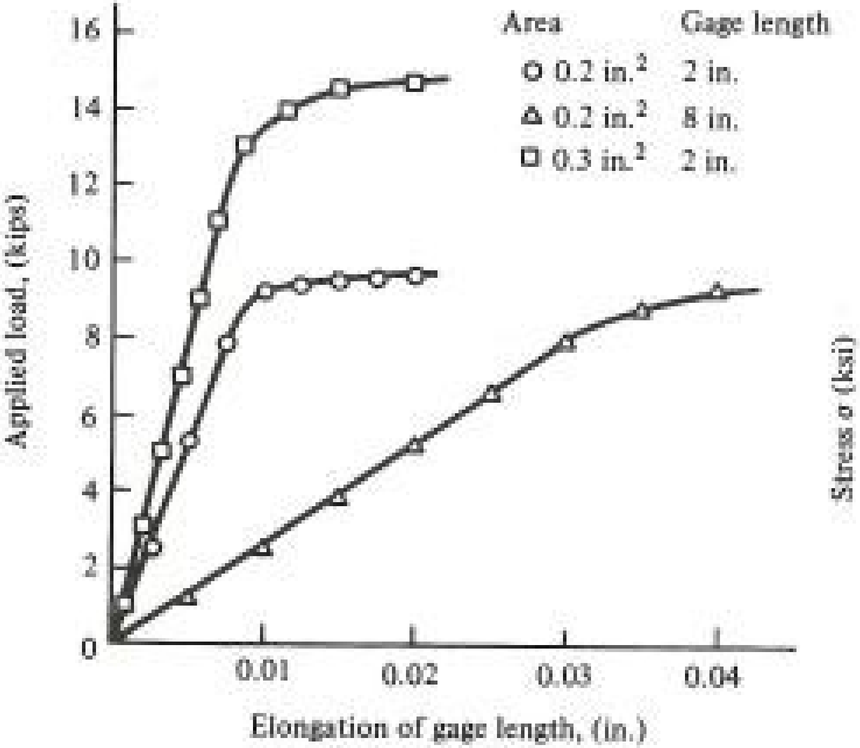
- σ = normal stress on a plane perpendicular to the longitudinal axis of the specimen

  1 Gigapascal=10^9 N/m^2 ~ 10^4 atmosphere
- P = applied load
- A = original cross sectional area
- ε = normal strain in the longitudinal direction

  dimensionless
- δ = change in the specimen’s gage length
- L = original gage length
- K = σ / ε == Young's modulus (Gpa)===stiffness==spring constant

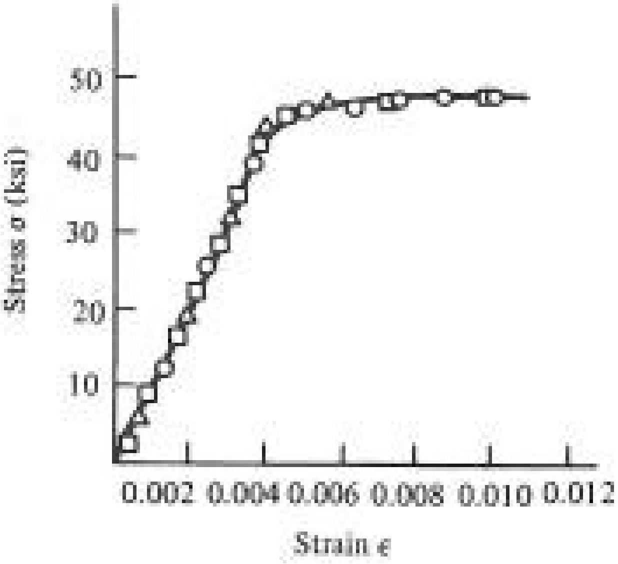
2017-T451 Aluminum Alloy

Load-deformation data



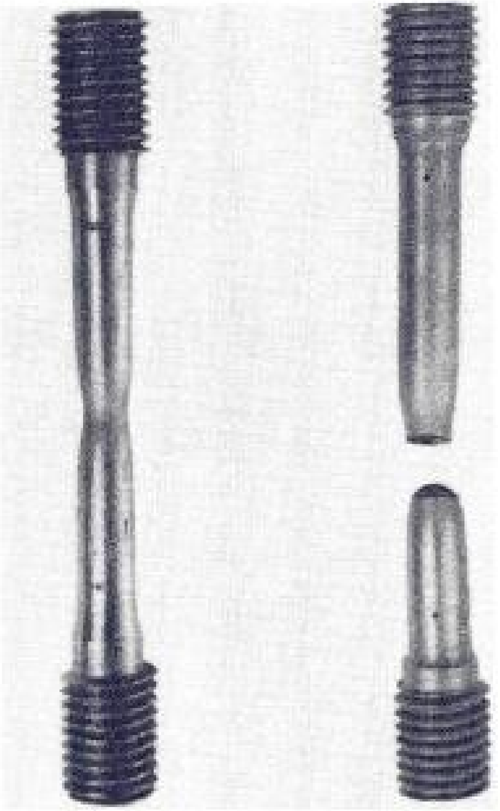
Load vs deformation
for three specimens

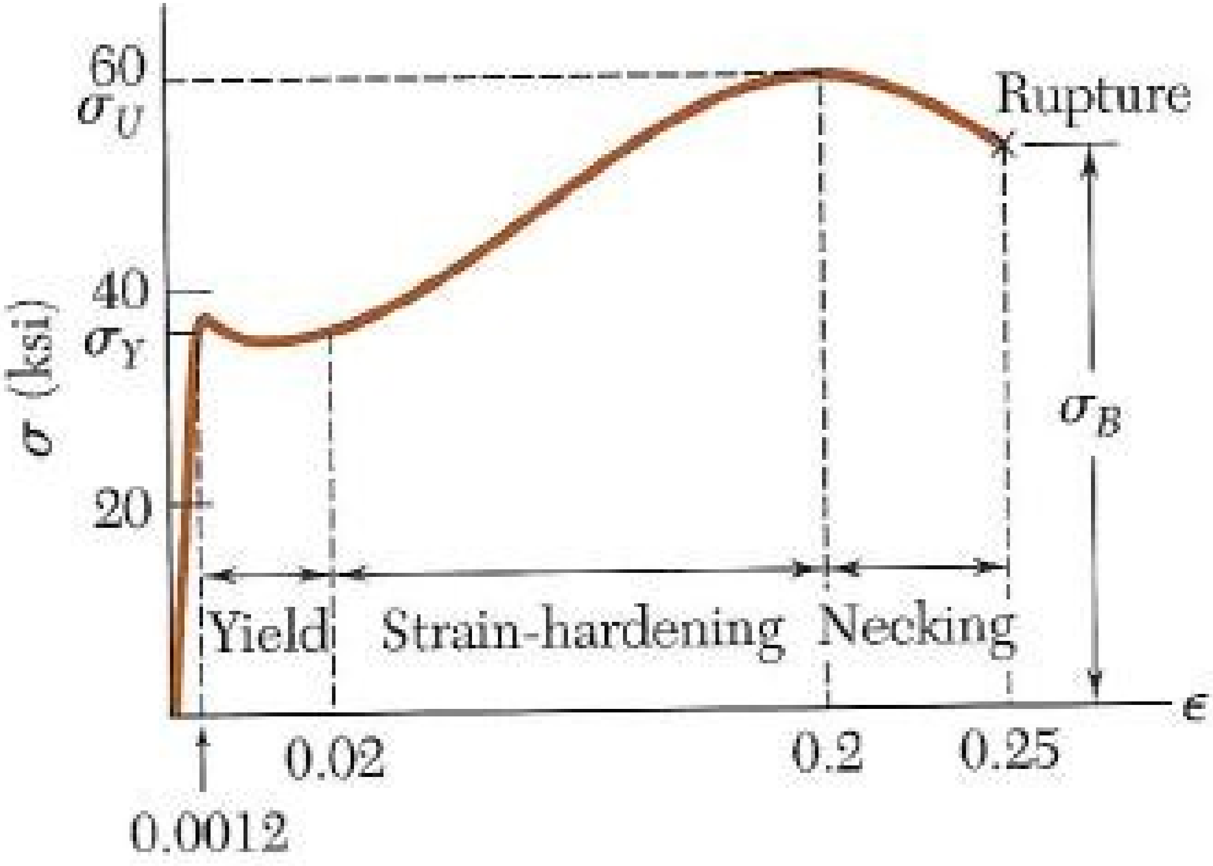
Stress-strain data



Mapped onto common
Stress vs Strain map

Stress vs Strain of steel rod shows: Hooke linear region, yield region, strain-hardening region, necking and failure





(*a*) Low-carbon steel

Ductile vs Brittle?

- Ductile Material – Materials that are capable of undergoing large strains (at normal temperature) before failure. An advantage of ductile materials is that visible distortions may occur before the loads become too large. Ductile materials are also capable of absorbing large amounts of energy prior to failure.
- Ductile materials include mild steel, aluminum and some of its alloys, copper, magnesium, nickel, brass, bronze and many others.
- Brittle Material – Materials that exhibit very little inelastic deformation. In other words, materials that fail in tension at relatively low values of strain are considered brittle.
- Brittle materials include concrete, stone, cast iron, glass and plaster.
-

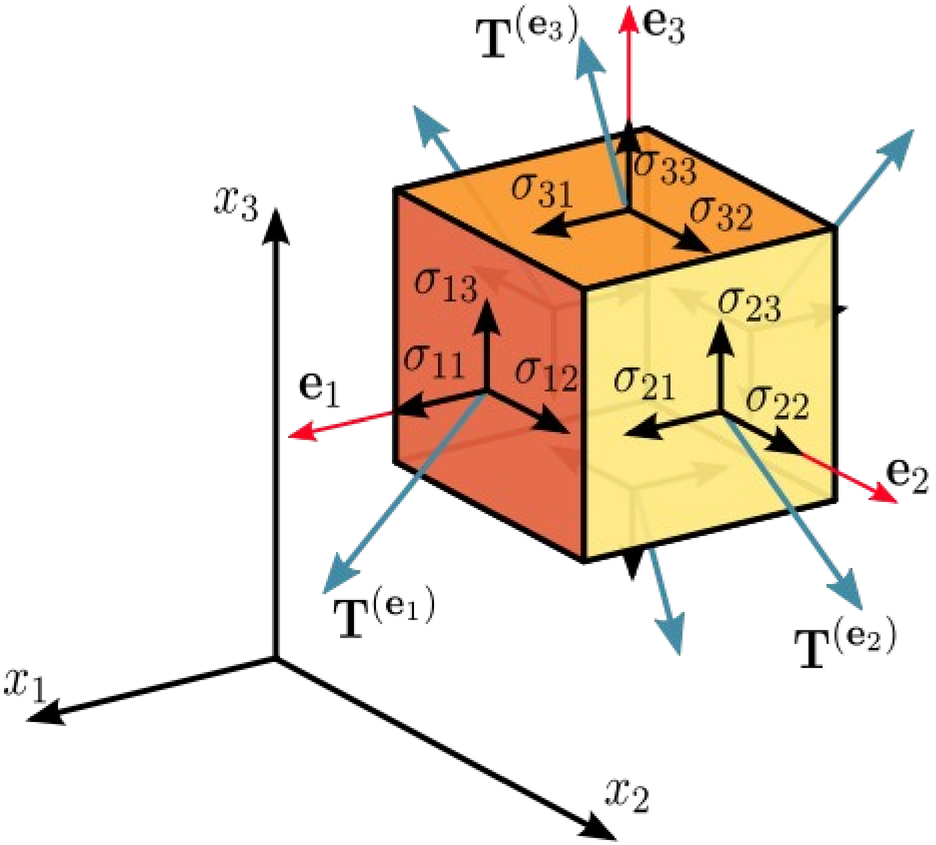
HDPE tensile test

stainless steel tensile test

Longitudinal and Transverse Stress

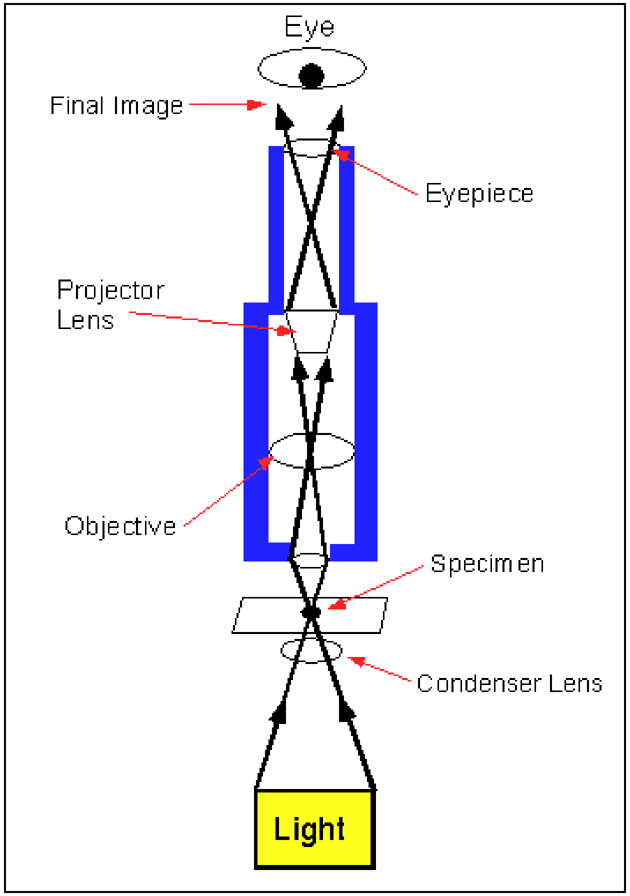
A complete description of the mechanical load on a solid requires three longitudinal stress components and six transverse (shear) components.

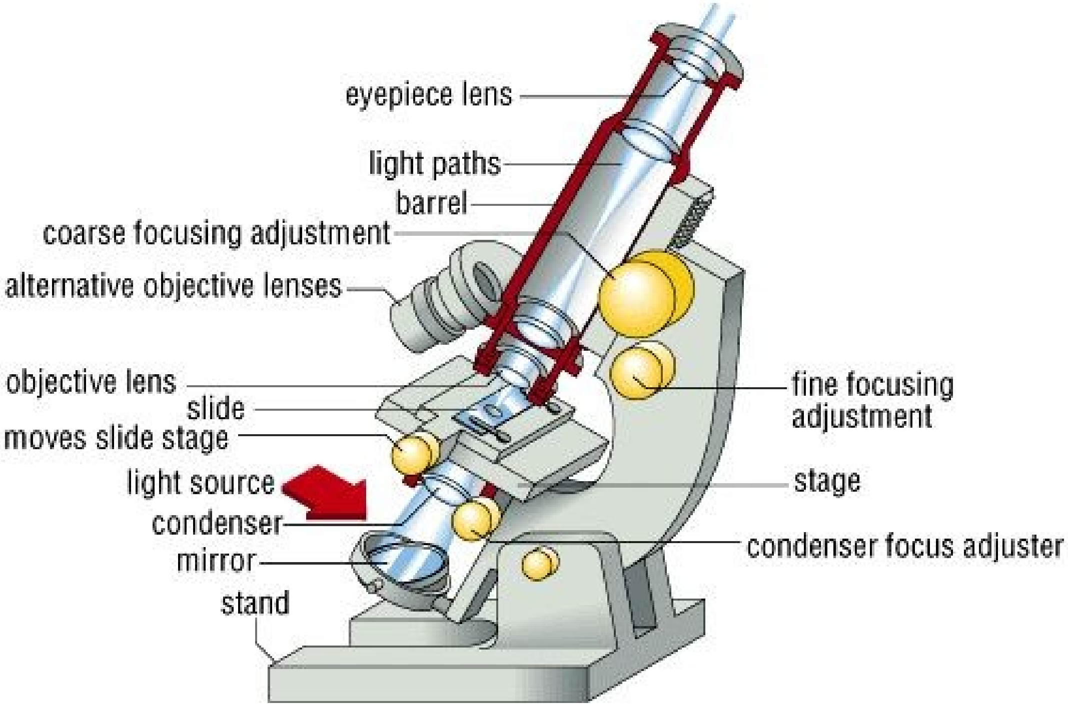
In Cauchy's world stress is described by a 3x3 matrix $[\sigma_{ij}]$ which causes the 3x3 strain response $[\varepsilon_{ij}]$



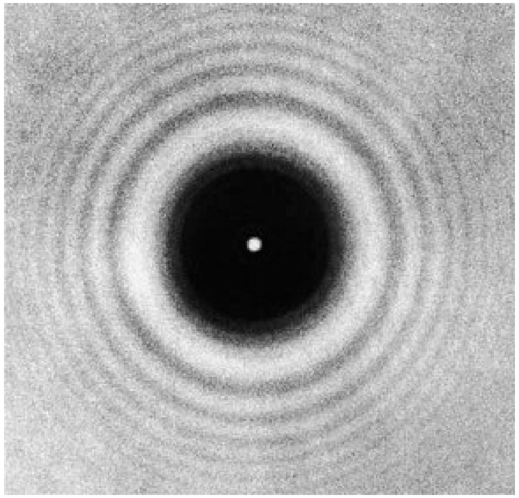
Principios de analise 2:

Micro-experimental:
microscopia otica, ultravioleta & infravermelho,
ultrasom,
raios-X & gamma...

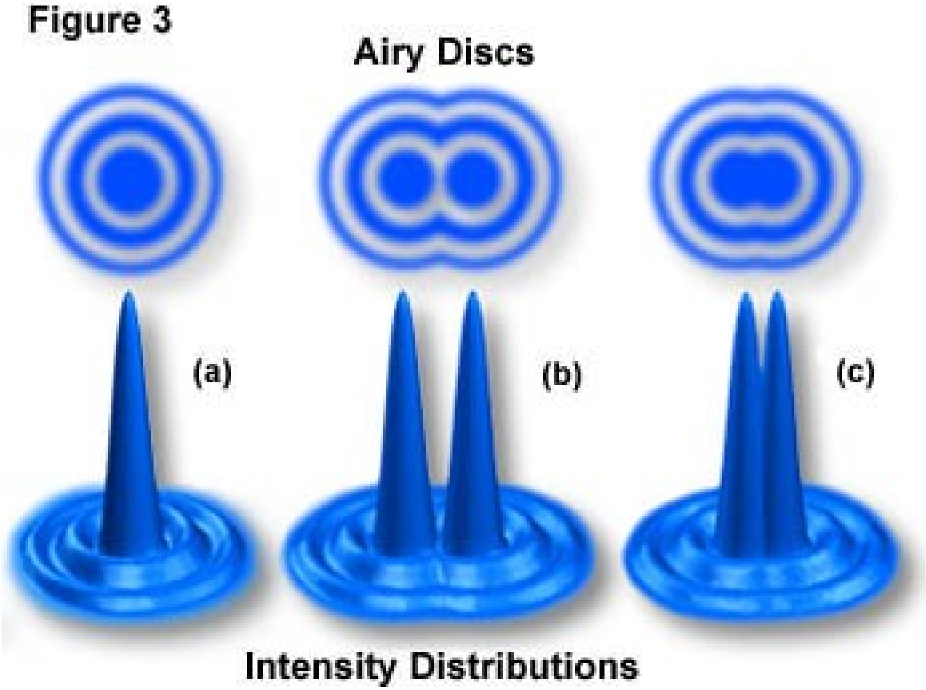




Traditional compound optical microscope usually has two sets of glass lenses and an eyepiece. The first true compound microscope was developed in 1609 in the Netherlands by Zacharias Janssen. Modern compound light microscopes, under optimal conditions, can magnify an object from 1000X to 2000X (times) the specimens original diameter. **Fluorescence microscopy** makes use of fluorescent dyes to illuminate samples, or to highlight the presence of particular substances within a sample. Various illumination systems are also used to highlight details.



Experimental diffraction pattern around a dark disk.
Hey, what`s that bright dot in the middle?



Schematic intensity field for one and two (nearby) sources seen through microscope/telescope

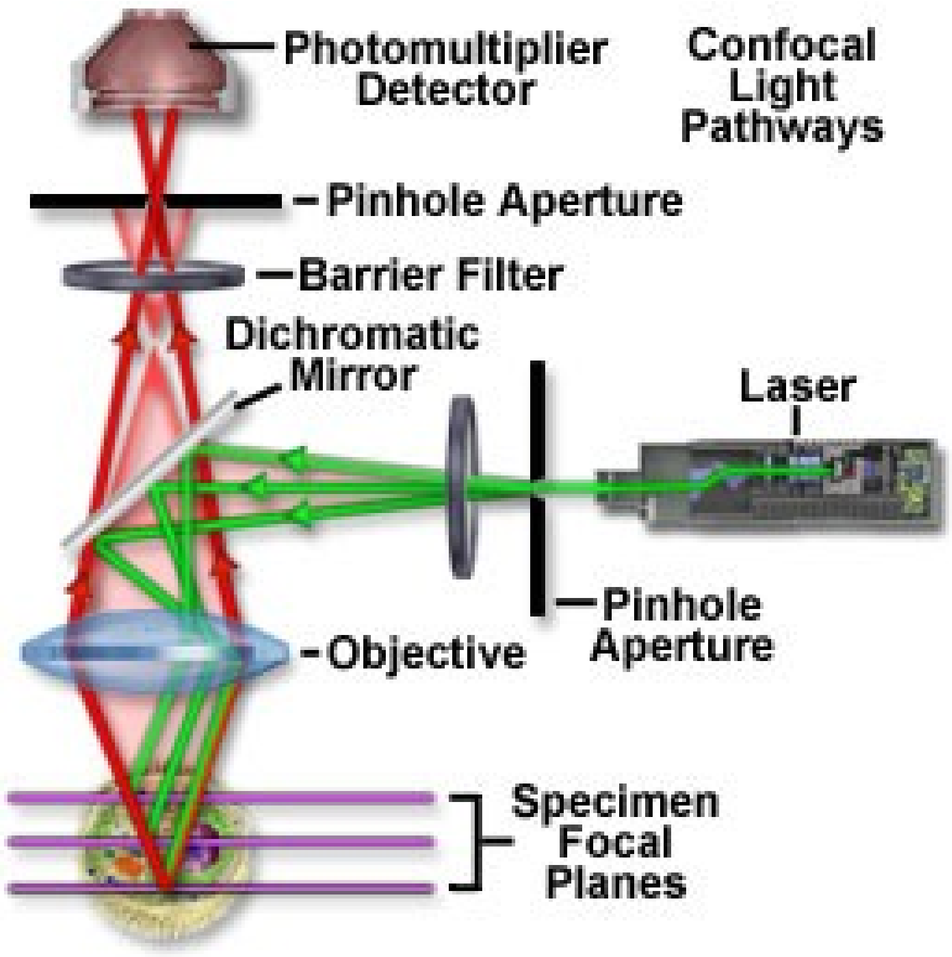
The observation of sub-wavelength structures with microscopes is difficult because of the **Abbe diffraction limit**. Ernst Abbe found in 1873 that light with wavelength λ, traveling in a medium with refractive index n and converging to a spot with angle θ will make a spot with radius

$$d = \lambda /2(n \sin \theta)$$

The denominator is called the numerical aperture and can reach about 1.4 in modern optics, hence the Abbe limit is roughly d=λ/2. With green light around 500nm the Abbe limit is 250nm which is large compared to most nanostructures or biological cells which have sizes on the order of 1μm and internal organelles which are much smaller

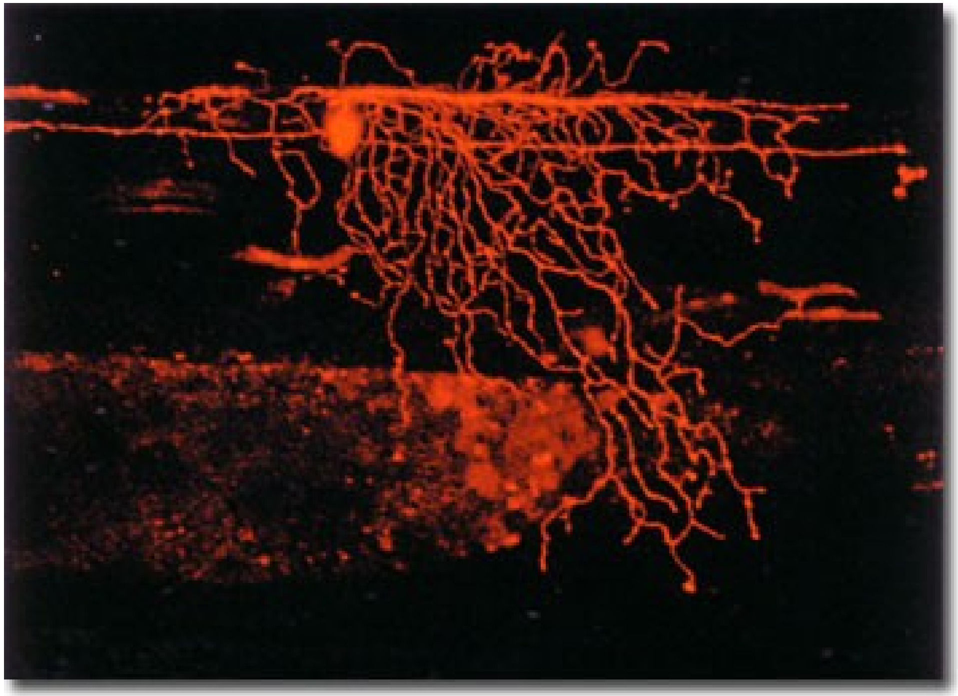
FluoViewTM FV1000 Confocal Laser Scanning Biological Microscope - A leader in the next generation of live cell confocal imaging systems, the FV1000 features simultaneous laser light stimulation and imaging by incorporating two laser scanners in a single compact design. Synchronization of these two functions ensures that cellular reactions occurring immediately following or during stimulation are not overlooked, a key feature in microscopes designed for FRAP, FLIP, and photo activation.

Laser scanning confocal microscopy represents one of the most significant advances in optical microscopy ever developed, primarily because the technique enables visualization deep within both living and fixed cells and tissues and affords the ability to collect sharply defined optical sections from which three-dimensional renderings can be created. The principles and techniques of confocal microscopy are becoming increasingly available to individual researchers as new single-laboratory microscopes are introduced. Development of modern confocal microscopes has been accelerated by new advances in computer and storage technology, laser systems, detectors, interference filters, and fluorophores for highly specific targets.



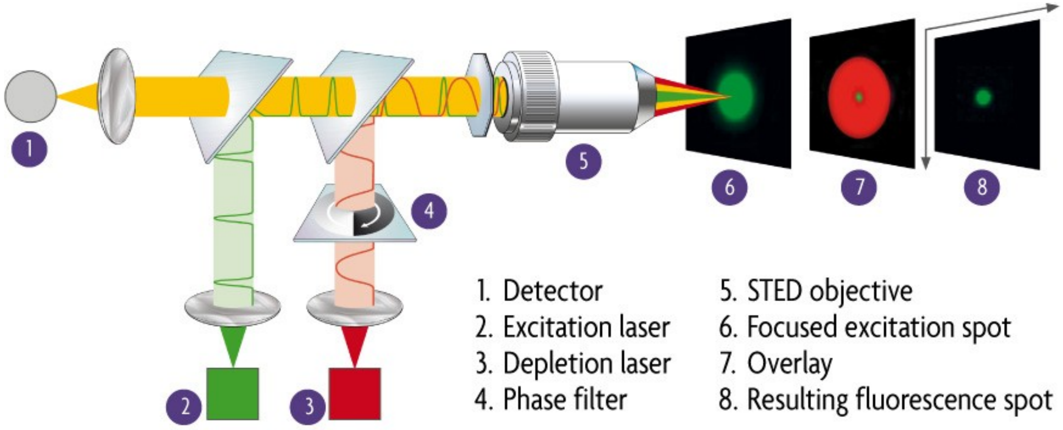
Fluorescent Protein Expression in Zebrafish Embryos

Spectral variants of the green fluorescent protein (**GFP**) are quite useful for double or triple labeling experiments or when targeting fluorescence expression with a particular laser system. The confocal image presented below is a three-dimensional volume render made from 5-micrometer serial optical sections of a zebrafish embryo labeled with a red fluorescent protein (**dsRED**). The image was provided by Yasuhiro Kamei and Shunsuke Yuba of the Institute for Molecular and Cellular Biology at Osaka University, in Japan.



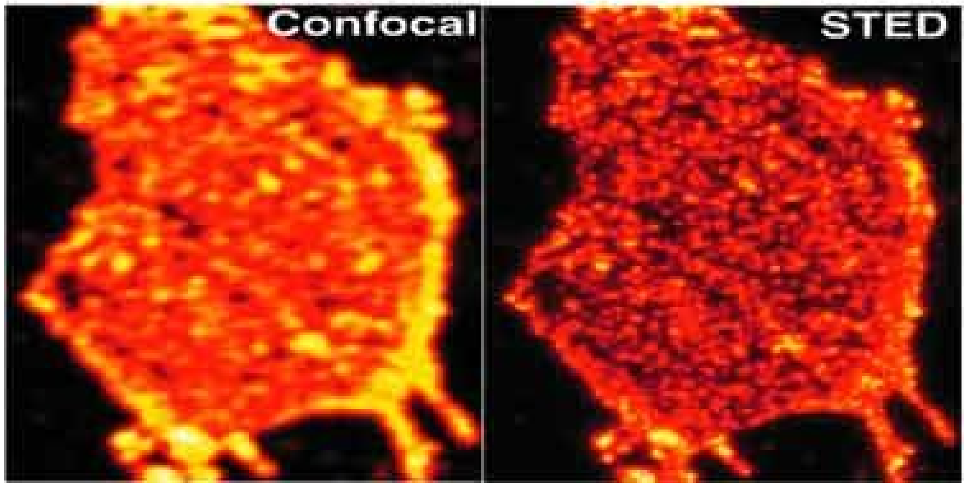
Try this:
confocal_microscope_simulator

A lot of tricks have been developed fairly recently, to get around the diffraction limit... one example: STED



1. Detector
2. Excitation laser
3. Depletion laser
4. Phase filter
5. STED objective
6. Focused excitation spot
7. Overlay
8. Resulting fluorescence spot

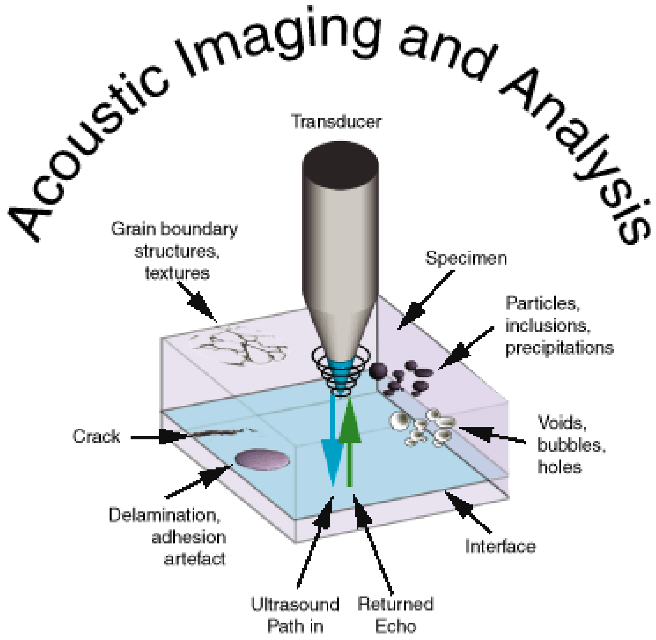
Principle of the Leica TCW STED microscopy.
The key to resolution enhancement in STED is downsizing of the fluorescent spot used to scan the sample, which is achieved through use of an upconverted confocal laser scanning microscope that utilizes two lasers. The first laser (2, green) excites the fluorophores of the sample the same way as a conventional confocal system. These pulses are directly followed by a pair of perpendicularly polarized beams from a red-shifted stimulating depletion laser – the STED pulse (3, red). This induces a depletion of the excited dye molecules, which de-excites them before they can emit any fluorescent light. Due to the depletion beam's doughnut-like shape (7), fluorescence is inhibited only in the outer regions of the illuminated spot. The result is a small, tightly focused, super-resolution spot that is scanned across the sample (8). This smaller spot overcomes the resolution-limiting effects of diffraction, resulting in more accurate scanning. Diagram courtesy of Leica Microsystems, Germany.

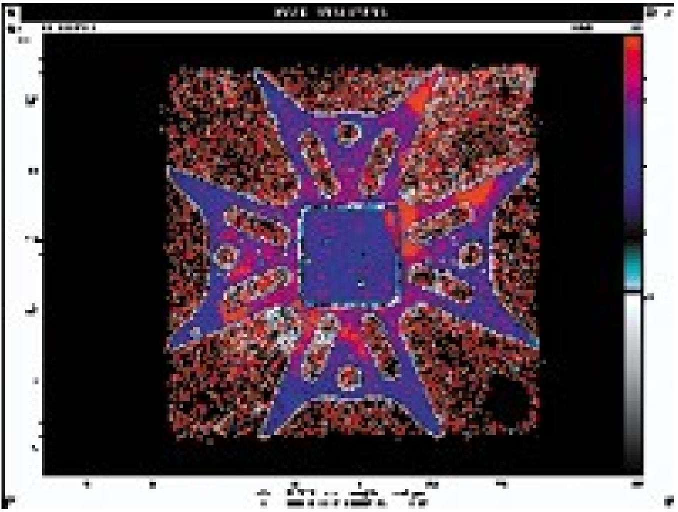


Resolution comparison of confocal versus STED-microscopy; plasma, mebrane patches immuno-stained against the SNARE protein SNAP25 secondary antibody labeled with Atto 532-NHS; Emission 540-570 nm, STED at 615 nm. The confocal image was recorded by simply turning off the STED beam with no other changes.

Stimulated emission depletion is a simple example of how higher resolution surpassing the diffraction limit is possible, but it has major limitations. STED is a fluorescence microscopy technique which uses a combination of light pulses to induce fluorescence in a small sub-population of fluorescent molecules in a sample. Each molecule produces a diffraction-limited spot of light in the image, and the center of each of these spots corresponds to the location of the molecule. As the number of fluorescing molecules is low the spots of light are unlikely to overlap and therefore can be placed accurately. This process is then repeated many times to generate the image. Stefan Hell of the Max Planck Institute for Biophysical Chemistry was awarded the 10th German Future Prize in 2006 for his development of the STED microscope.

Ultrasound- piezoelectric drivers/receiver arrays operating over 1-100 Mhz for non-destructive imaging. Bats, dolphins, etc. use the band 20-100 Khz for imaging. Medical applications are 1-20 Mhz.





Ultrasound permits looking 'below the surface' on many scales- from microchips, to babies, to aircraft wings, to oil ducts

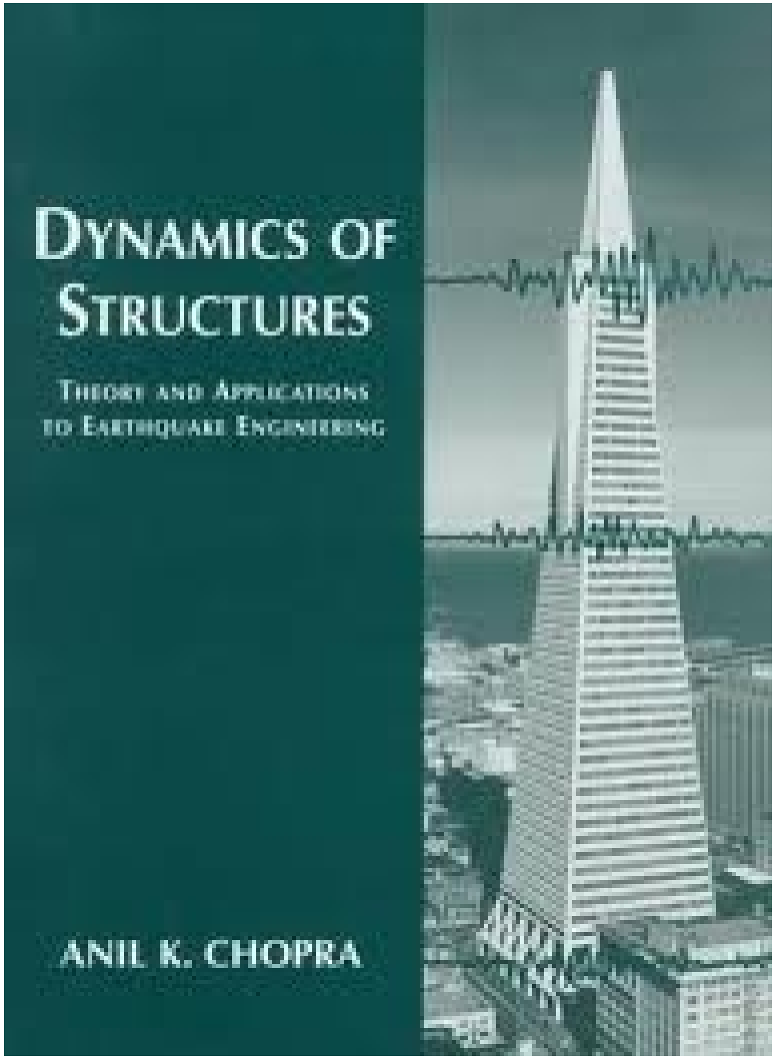
Modelos na escala de microns ate metros – analise de elemento finitos; o bom e velho Newton

Syllabus for an online course in continuum mechanics@Wikiversity

Mathematical Preliminaries
Set notation
Functions
Vectors
Matrices
Tensors
Useful tensor algebra identities
Useful relations between tensors and vectors
Curl of the gradient of a vector
Relations between surface and volume integrals
Leibniz formula in one dimension
Leibniz formula in three dimensions
Partial differential equations
Variational calculus
Kinematics
Motion, displacement, velocity, acceleration
Strains and deformations
Polar decomposition
Spectral decompositions of kinematic quantities
Volume change and area change
Time derivatives and rate quantities
Objectivity of kinematic quantities
Stress measures and stress rates
Stress measures
Deviatoric and volumetric stress
Objective stress rates
Balance laws
Governing equations and thermodynamics
Balance of mass
Balance of linear momentum
Balance of angular momentum
Balance of energy
Clausius-Duhem inequality
Constitutive relations
Thermoelasticity
Relation between Cauchy stress and Green strain
Maxwell relations for thermoelasticity
Balance of energy
Clausius-Duhem inequality
Specific heat relations
Nonlinear Elasticity
Plasticity
Viscoplasticity
Viscoelasticity.

Principles of continuum mechanics appear simple, but applications to real-world materials problems lead to subtle nonlinear mathematics, and eventually finite-element computer models

Glacier flows determine in part pace of global warming and sea-level rise. Their dynamics are partially understood.



DYNAMICS OF STRUCTURES

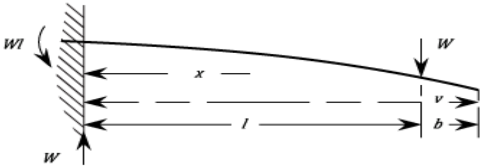
THEORY AND APPLICATIONS TO EARTHQUAKE ENGINEERING

ANIL K. CHOPRA

Try This: SF_Oakland bay bridge

Even the simplest beam-deflection problem is highly nonlinear:

The out-of-plane displacement *w* of a beam is governed by the Euler-Bernoulli Beam Equation,



$$\frac{d^2}{dx^2}\left[EI\frac{d^2w}{dx^2}\right]=p$$

where *p* is the distributed loading (force per unit length) acting in the same direction as *y* (and *w*), *E* is the Young's modulus of the beam, and *I* is the area moment of inertia of the beam's cross section.

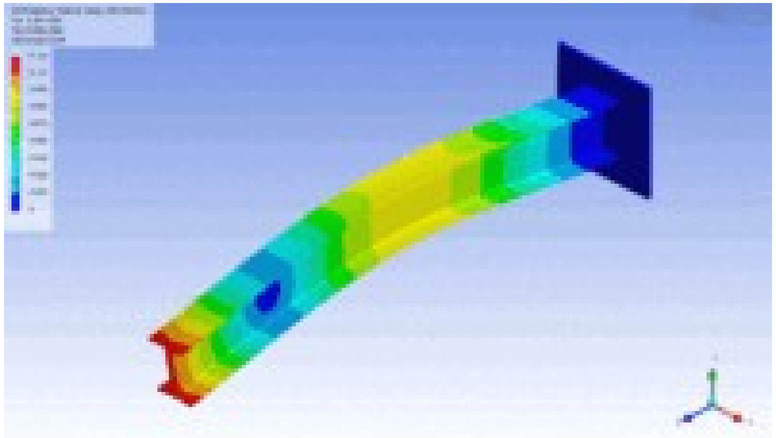
If *E* and *I* do not vary with *x* along the length of the beam, then the beam equation simplifies to,

$$EI\frac{d^4w}{dx^4}=p$$

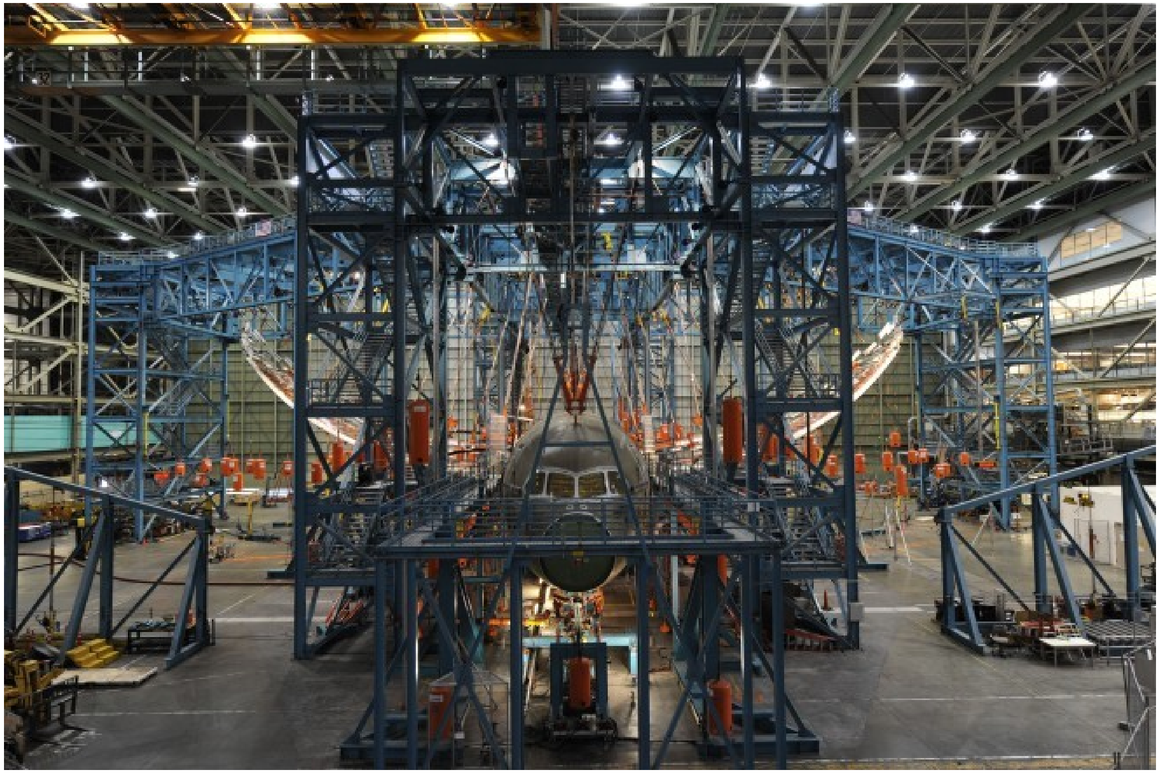
Of course, time-dependent stress-strain relations are more fun!!

$$\frac{\partial^2}{\partial x^2}\left(EI\frac{\partial^2 w}{\partial x^2}\right) = -\mu\frac{\partial^2 w}{\partial t^2} + q(x)$$

Time-dependent Euler-Bernouilli equation for
A loaded beam



Finite element computer models
And graphics are essential tools

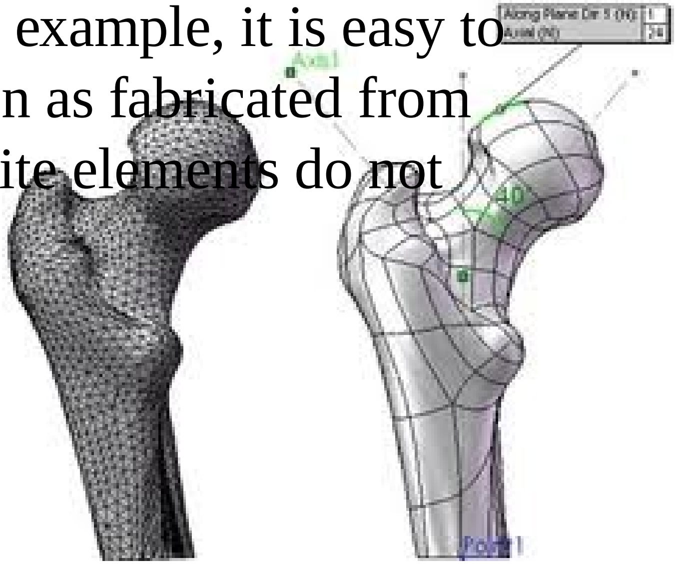


Boeing 787 wings at
150% design overload

What is the Finite Element Method?

The finite element method (FEM) is the dominant discretization technique in structural mechanics. The basic concept in the physical interpretation of the FEM is the subdivision of the mathematical model into disjoint (non-overlapping) components of simple geometry called finite elements or elements for short. The response of each element is expressed in terms of a finite number of degrees of freedom characterized as the value of an unknown function, or functions, at a set of nodal points.

The response of the mathematical model is then considered to be approximated by that of the discrete model obtained by connecting or assembling the collection of all elements. The disconnection-assembly concept occurs naturally when examining many artificial and natural systems. For example, it is easy to visualize an engine, bridge, building, airplane, or skeleton as fabricated from simpler components. Unlike finite difference models, finite elements do not overlap in space.



FEM model of femur; coarse grid for whole body mechanics, fine grid for prosthesis design/simulation