EMS412U
Mathematical and Computational Modelling-1

Statics – Introduction

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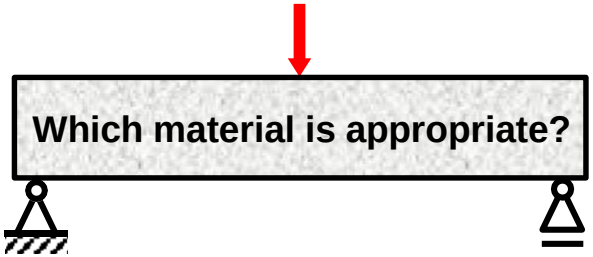
Engineering Mechanics: Statics

Solution of design problems:

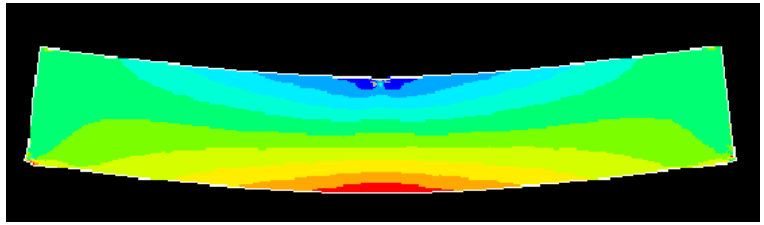
- **Description** of the problem (geometry, material, load cases, boundary and initial conditions, etc. uncertainties);
- Derivation of an appropriate **mechanical model** for material behaviour, loads etc.;
- Evaluation of the validity of the model – be careful when you extrapolate.
- **Solution** of the problem often via numerical methods: calculation by hand, computational methods (finite element methods FEM, computational fluid dynamics CFD);
- **Visualisation and plausibility control** of the results.

Design criteria: What is the purpose and how much can I spend?

2. Mechanical model



3. Solution and 4. visualisation



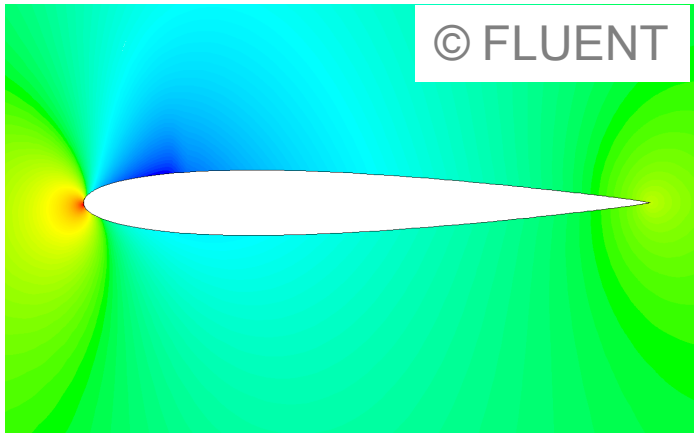
Have I included all important aspects? Was the model too simplified?

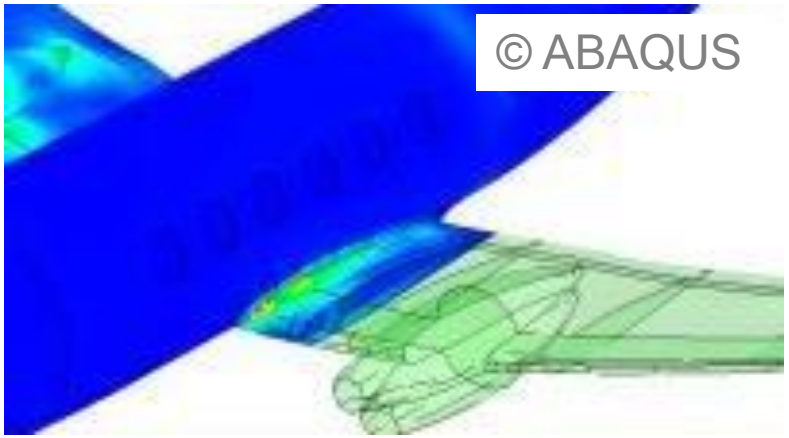
Fluid and Solid Mechanics

Two main fields of Mechanics:

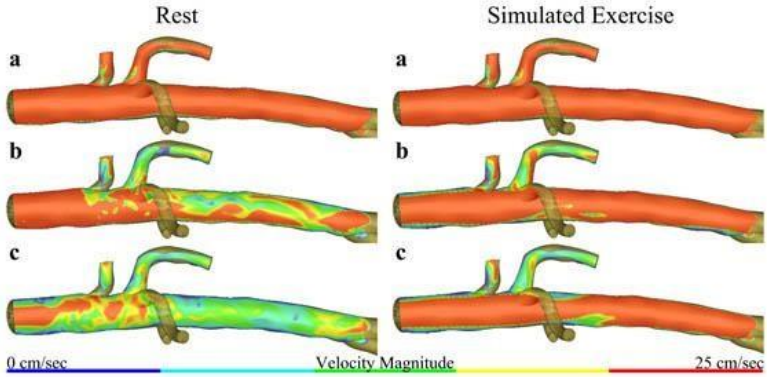
- Fluid mechanics
- Solid mechanics

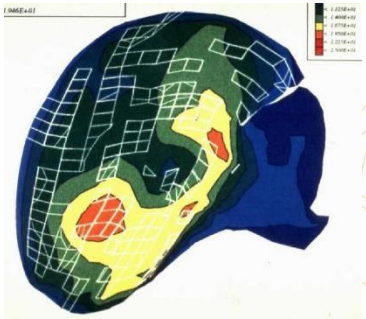
Fluid mechanics Example:
Pressure around an airfoil.



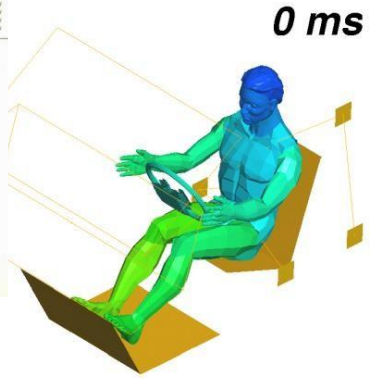


Cardiovascular deseases





ttb.eng.wayne.edu/brain/



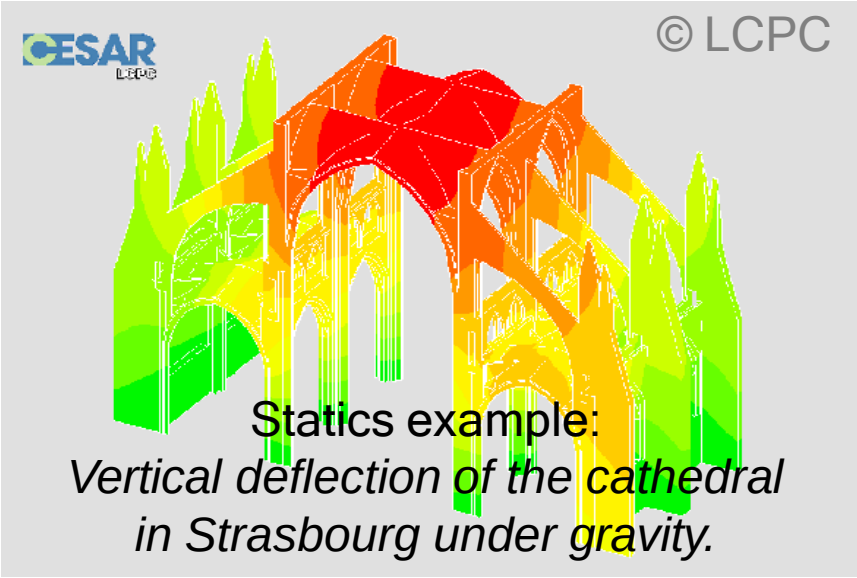
Statics and Dynamics

Two main types of Mechanics:

- **Statics**: loading and reactions are independent of the time; nothing moves
- **Dynamics**: loading and reactions depend on time.; the objects are moving

- Sometimes so-called **quasi-statics** are analysed; here the load velocity is very small such that it can be regarded as independent of time.

Attention:
For dynamic cases, failure may occur even though no high loadings are applied.
E.g. due to fatigue or excitation at the natural frequency.



Statics example:
Vertical deflection of the cathedral in Strasbourg under gravity.

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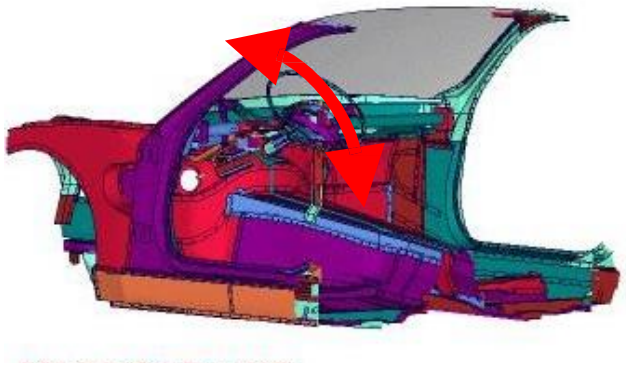


Dynamics example:
Vibration of the steering wheel.

Basic Concepts and Quantities

Basic Quantities:

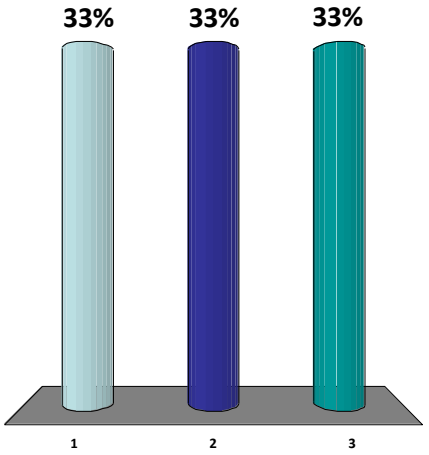
• Length	l	[m]
• Time	t	[s]
• Velocity	v	[ms^{-1}]
• Acceleration	a	[ms^{-2}]
• Mass	m	[kg]
• Weight	W	[N]
• Force	F	[N]
• Moment	M	[Nm]
• Deformation	d	[m]
• Stress	σ	[Pa]
• Strain	ε	[-]
• Work	W	[Nm]
• Energy	E	[J]

Concepts:

- **Mass point:** without any physical extension but with mass.
- **Rigid body:** consists of several masses but is undeformable; can undergo rotation and translation.
- **Single force:** a load, which acts on a single point of an object.

How many of these Quantities are you familiar with?

1. 0-4
2. 5-9
3. 10-13



Fundamentals

Decimal multiples and sub-multiples

1,000,000,000	10^9	Giga	G
1,000,000	10^6	Mega	M
1,000	10^3	Kilo	k
0.001	10^{-3}	Milli	m
0.000 001	10^{-6}	Mikro	μ
0.000 000 001	10^{-9}	Nano	n

Unit conversion

	Unit (FPS)	Unit (SI)
Force	1 lb	4.482 N
Mass	1 slug	14.5938 kg
Length	1 ft	0.3048 m
Length	1 inch	0.0254 m
Length	1 mile	1,609.0 m
Liquid	1 pint	0.568 l
Liquid	1 gallon	4.546 l
Temperature		$x\,°F = \frac{5}{9}(x-32)°C$

Greek alphabet

Alpha	α Α	Ny	ν Ν
Beta	β Β	Xi	ξ Ξ
Gamma	γ Γ	Omikron	ο Ο
Delta	δ Δ	Pi	π Π
Epsilon	ε Ε	Rho	ρ Ρ
Zeta	ζ Ζ	Sigma	σ Σ
Eta	η Η	Tau	τ Τ
Theta	θ ϑ	Ypsilon	υ Υ
Jota	ι Ι	Phi	ϕ Φ
Kappa	κ Κ	Chi	χ Χ
Lambda	λ Λ	Psi	ψ Ψ
My	μ Μ	Omega	ω Ω

SI = International Units System