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Overview

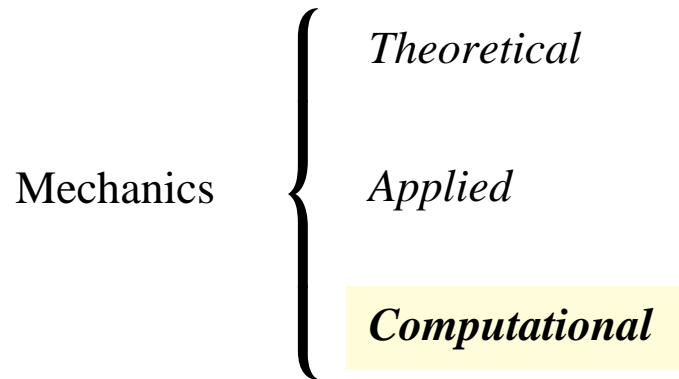
Course Coverage

This course consists of three Parts:

- I. *Finite Element Basic Concepts*
- II. *Formulation of Finite Elements*
- III. *Computer Implementation of FEM*

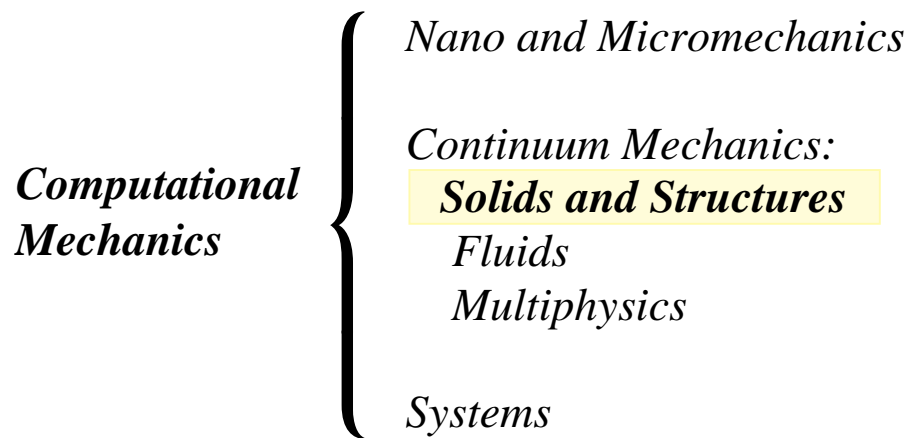
Where the Course Fits

The field of Mechanics can be subdivided into 3 major areas:



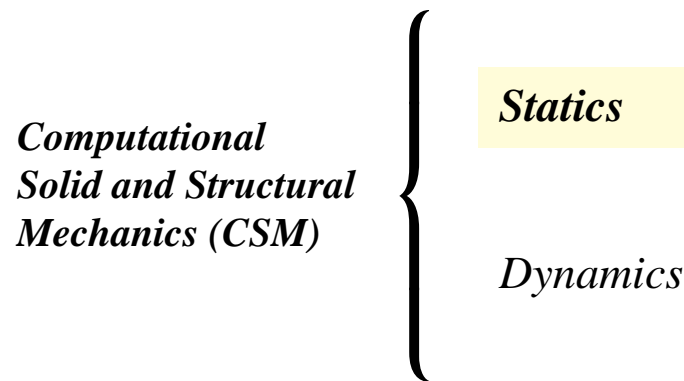
Computational Mechanics

Branches of *Computational Mechanics* can be distinguished according to the physical focus of attention



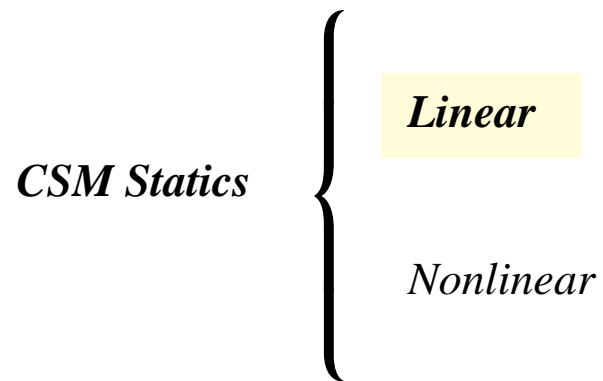
Computational Solid and Structural Mechanics

A convenient subdivision of problems in Computational Solid and Structural Mechanics (CSM) is



CSM Statics

A further subdivision of problems in CSM Statics is



CSM Linear Statics

For the numerical simulation on the computer we must now chose a *spatial discretization method*:

CSM Linear Statics

Finite Element Method

Finite Difference Method

Boundary Element Method

Finite Volume Method

Spectral Method

Mesh-Free Method

CSM Linear Statics by FEM

Having selected the FEM for *discretization*, we must next pick a *formulation and a solution method*:

Formulation of FEM Model { **Displacement**
Equilibrium
Mixed
Hybrid

Solution of FEM Model { **Stiffness**
Flexibility
Mixed

Summarizing: This Course Covers

Computational structural mechanics

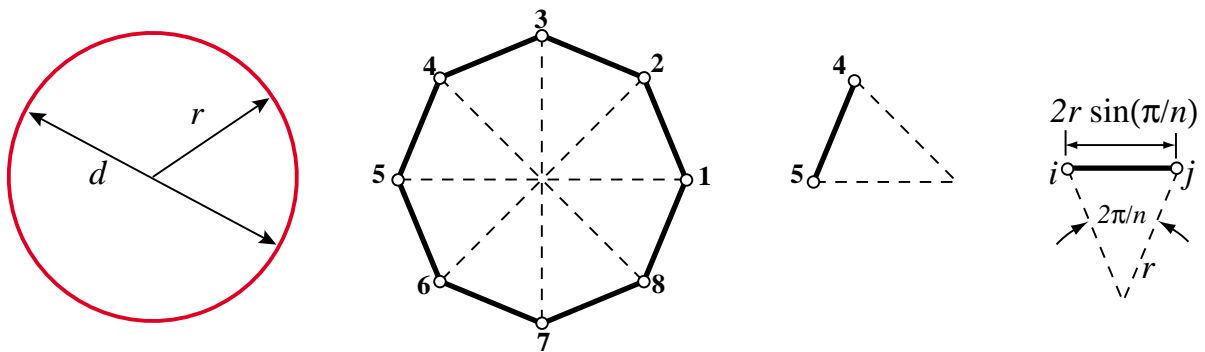
Linear static problems

Spatially discretized by displacement-formulated FEM

Solved by the stiffness method

What is a Finite Element?

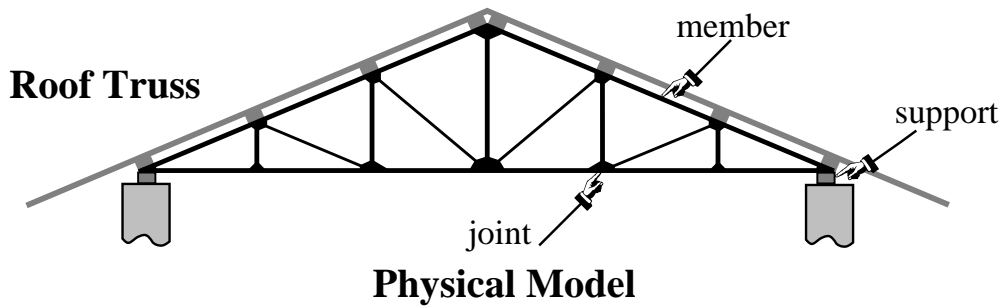
Archimedes' problem (*circa* 250 B.C.): rectification of the circle as limit of inscribed regular polygons



Computing π "by Archimedes FEM"

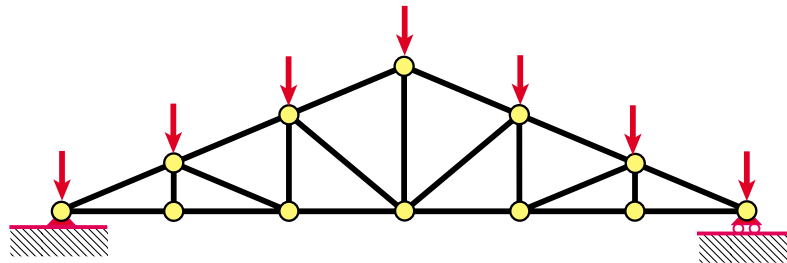
n	$\pi_n = n \sin(\pi/n)$	Extrapolated by Wynn- ϵ	Exact π to 16 places
1	0.0000000000000000		
2	2.0000000000000000		
4	2.828427124746190	3.414213562373096	
8	3.061467458920718		
16	3.121445152258052	3.141418327933211	
32	3.136548490545939		
64	3.140331156954753	3.141592658918053	
128	3.141277250932773		
256	3.141513801144301	3.141592653589786	3.141592653589793

The Idealization Process for a Simple Structure



IDEALIZATION & DISCRETIZATION

Mathematical *and* Discrete Model



Two Interpretations of FEM for Teaching

Physical

Breakdown of structural system into components (elements) and reconstruction by the assembly process

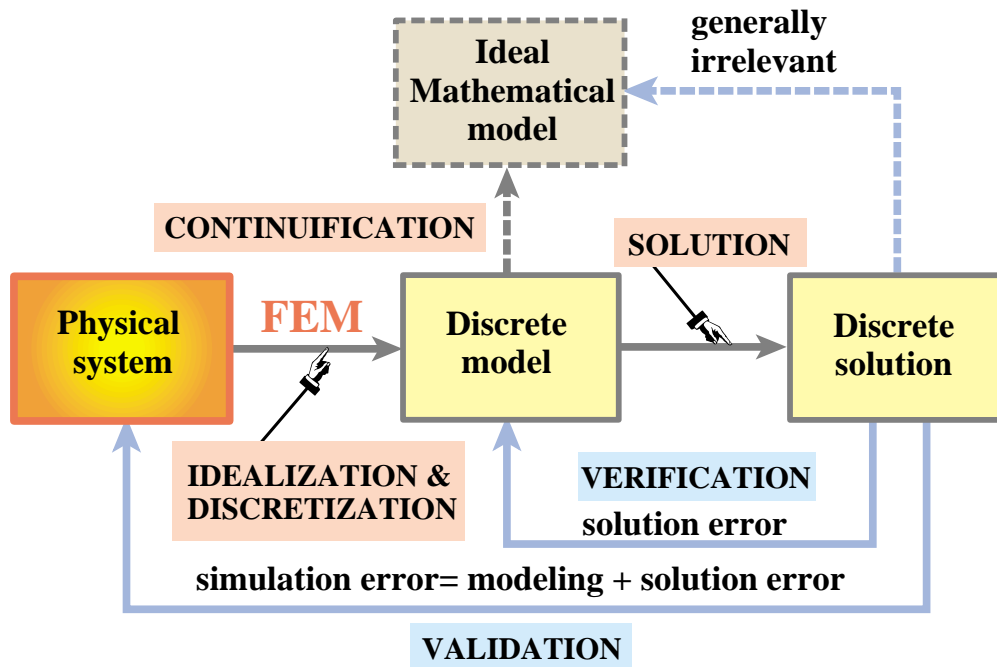
Emphasized in Part I

Mathematical

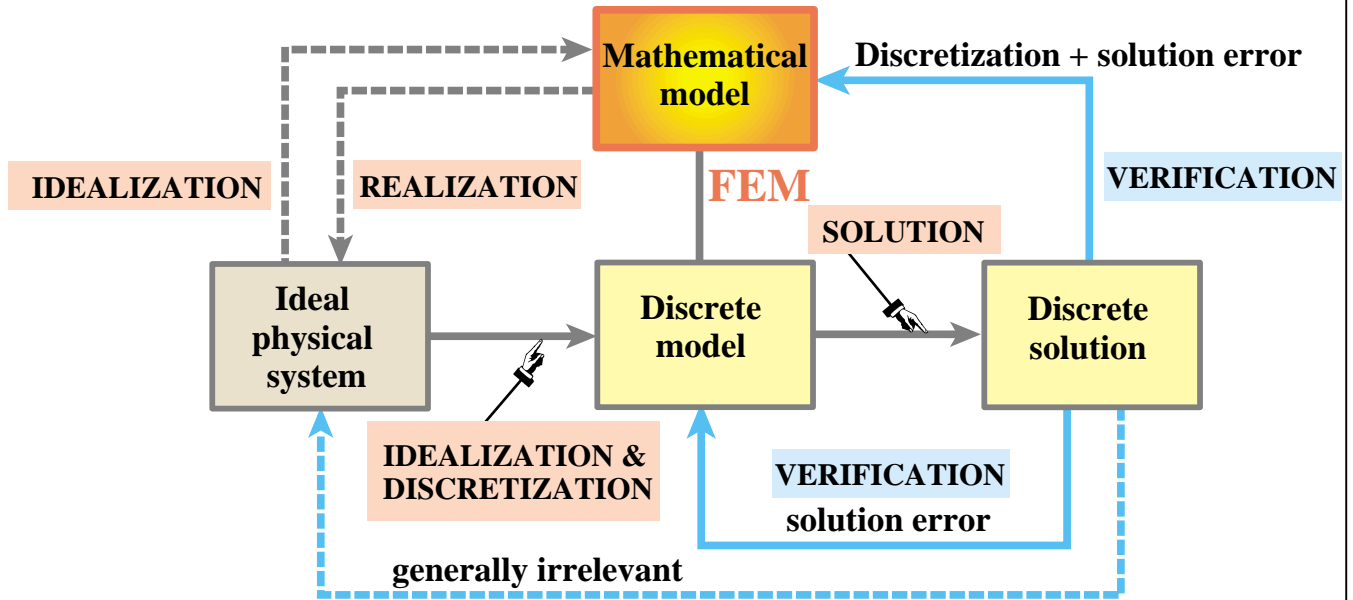
Numerical approximation of a Boundary Value Problem by Ritz-Galerkin discretization with functions of local support

Emphasized in Part II

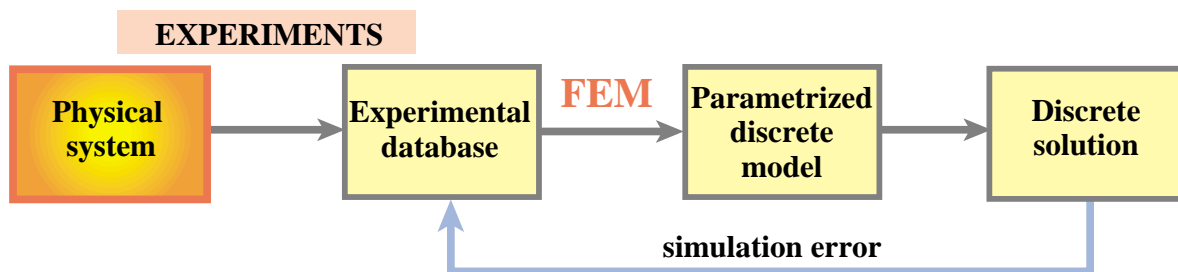
FEM in Modeling and Simulation: Physical FEM



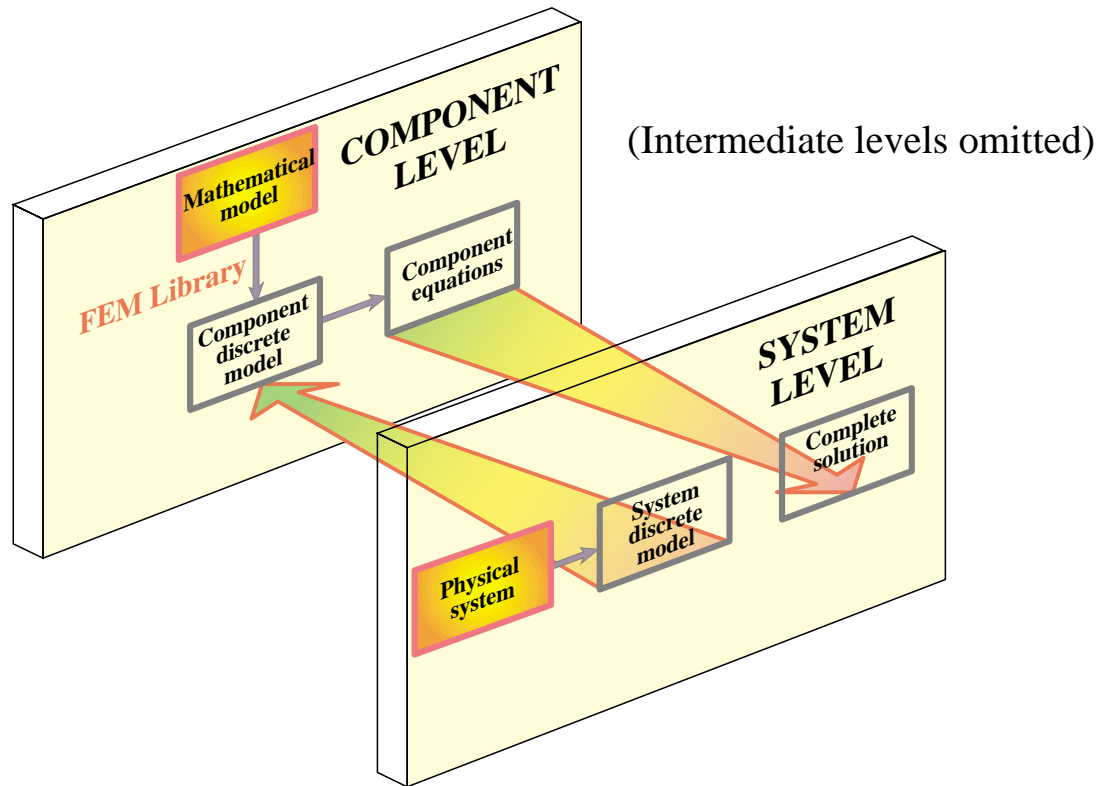
FEM in Modeling and Simulation: Mathematical FEM



Model Updating in Physical FEM



Synergy Between Mathematical and Physical FEM



Recommended Books for Linear FEM

Basic level (reference): Zienkiewicz & Taylor (1988), Vols I (1988), II (1993). A comprehensive upgrade of the 1977 edition. Primarily an encyclopedic reference work that provides a panoramic coverage of FEM, as well as a comprehensive list of references. Not a textbook. A fifth edition has appeared.

Basic level (textbook): Cook, Malkus & Plesha (1989); this third edition is fairly comprehensive in scope and up to date although the coverage is more superficial than Zienkiewicz & Taylor.

Intermediate level: Hughes (1987). It requires substantial mathematical expertise on the part of the reader. Recently reprinted by Dover..

Mathematically oriented: Strang & Fix (1973). Most readable mathematical treatment although outdated in several subjects.

Most fun (if you like British "humor"): Irons & Ahmad (1980)

Best value for the \$\$\$: Przemieniecki (Dover edition 1985, ~\$16). Although outdated in many respects (e.g. the word "finite element" does not appear in this reprint of the original 1966 book), it is a valuable reference for programming simple elements.

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