Introduction to Structural Analysis

Mark A. Austin

University of Maryland

austin@umd.edu
ENCE 353, Fall Semester 2020

September 3, 2020

Overview

Part 1

Introduction

Definition of Structural Mechanics

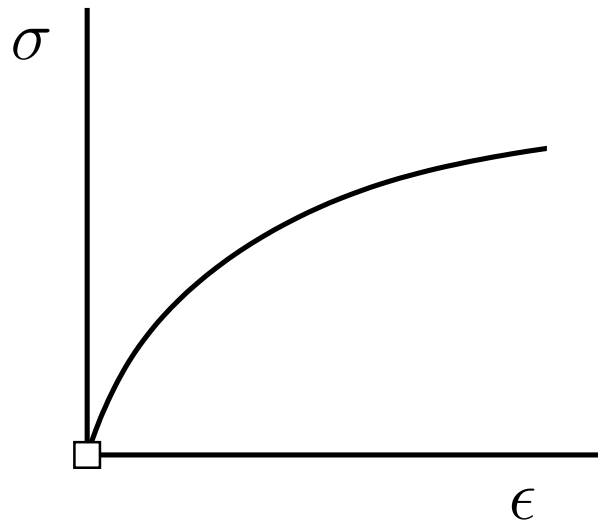
Mechanics. Branch of science that deals with response of matter to forces.

Civil Engineering:

- Structural mechanics (σ - ϵ): material displacement.
- Geomechanics (σ - ϵ): pressure, temperature, displacements.
- Fluid mechanics (σ - ϵ): pressure, velocities.

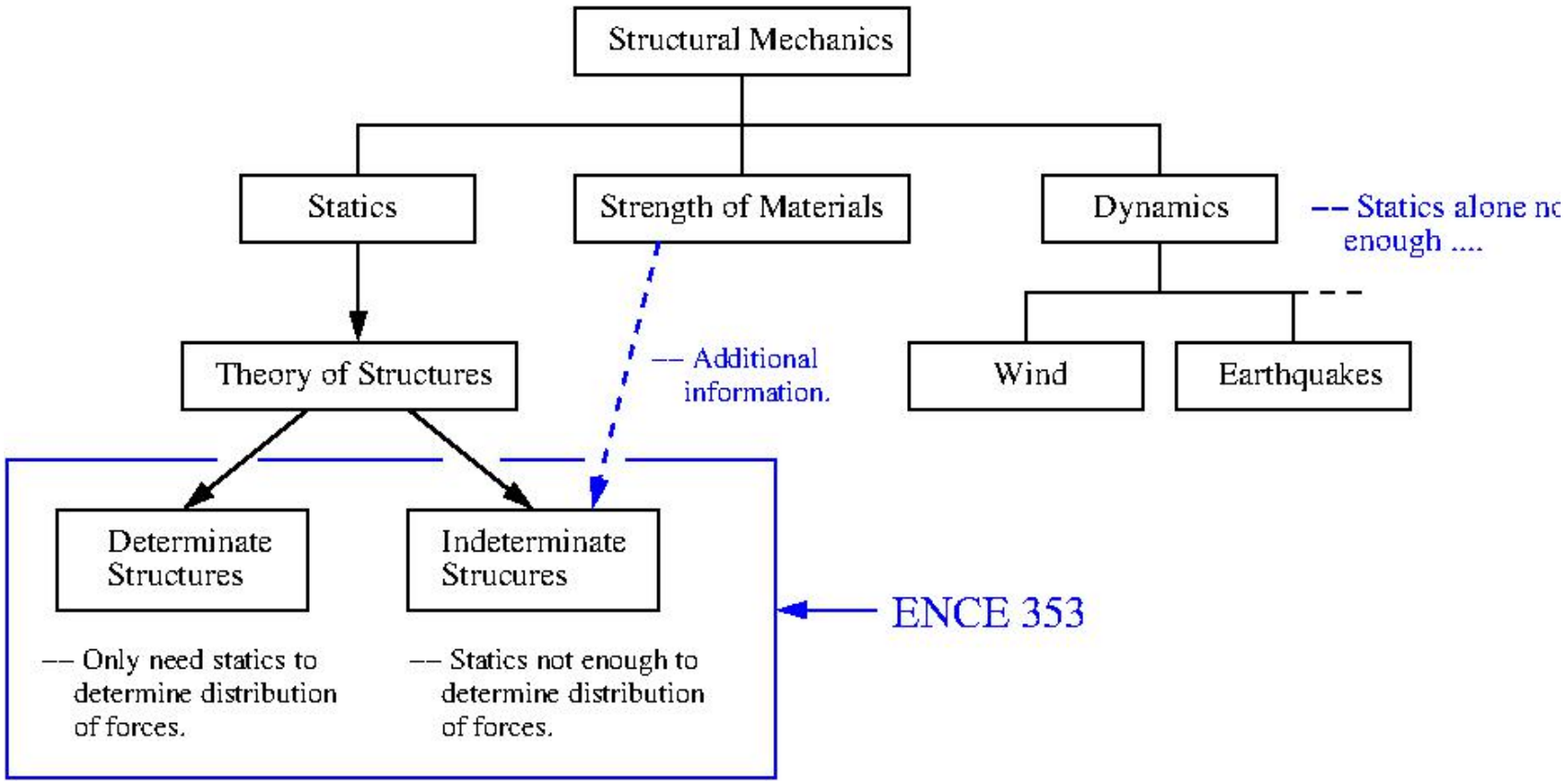
Other domains:

- Biomechanics (σ - ϵ): eye, heart, biological systems that grow!



Structural Mechanics and Analysis

Structural Mechanics → Static / Dynamic Analysis of Structures:



Structural Mechanics and Analysis

Scope of this class:

- We will be concerned with structural systems that are attached to the ground.

Pathway forward:

- Connect mechanics to analysis ...
- Connect analysis to design ...
- Theory of structural analysis ...

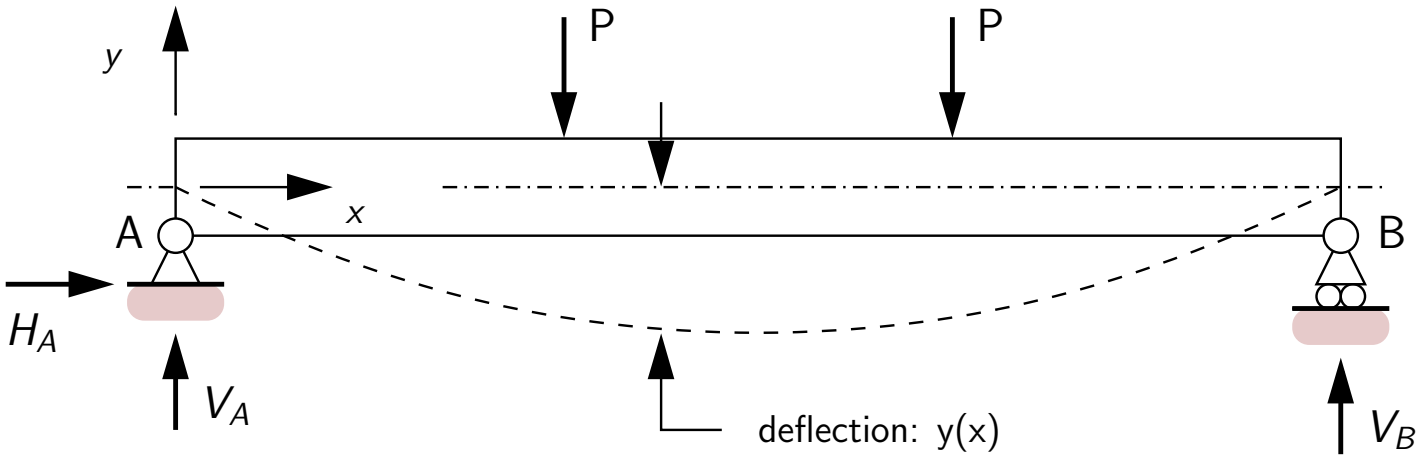
  Statically determinate structures ...

  Statically indeterminate structures ...

- Simplifying assumptions ...

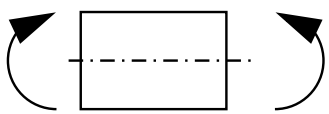
Connecting Mechanics to Analysis

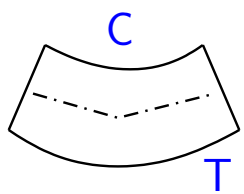
Structural Mechanics and Analysis



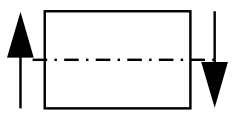
Internal Forces

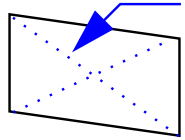
Bending Moment $M(x)$



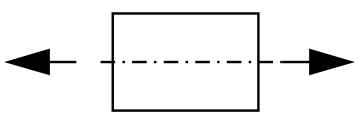


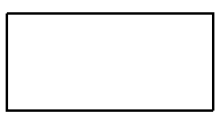
Shear Force $V(x)$





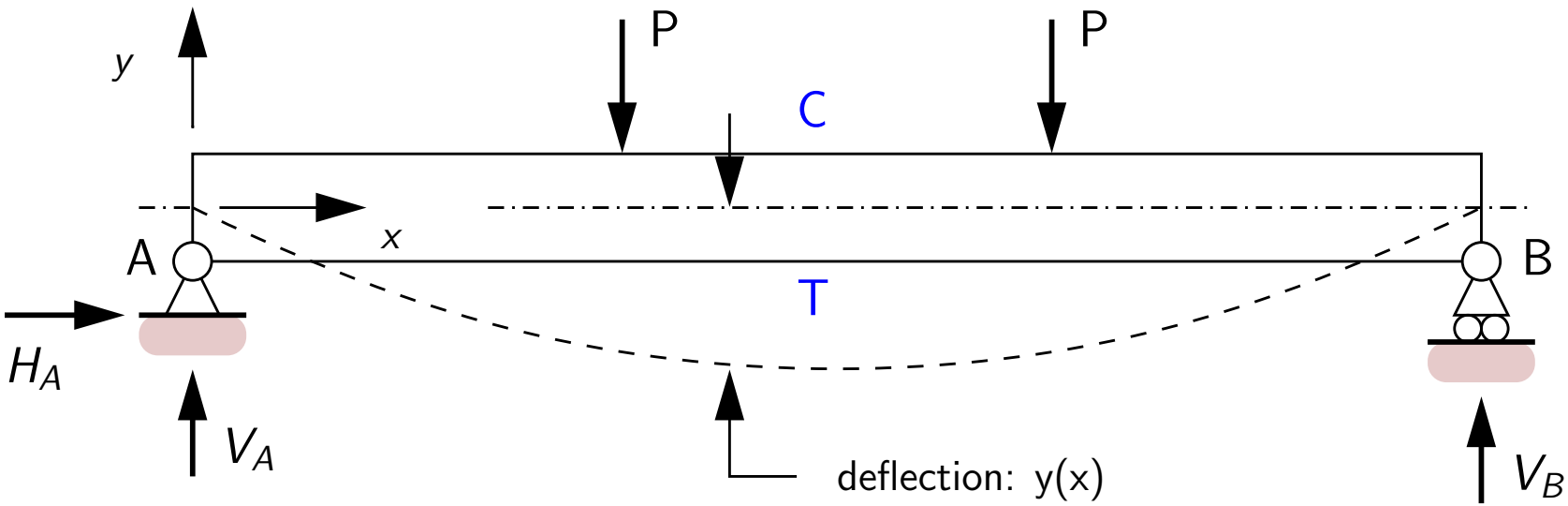
Axial Force $N(x)$



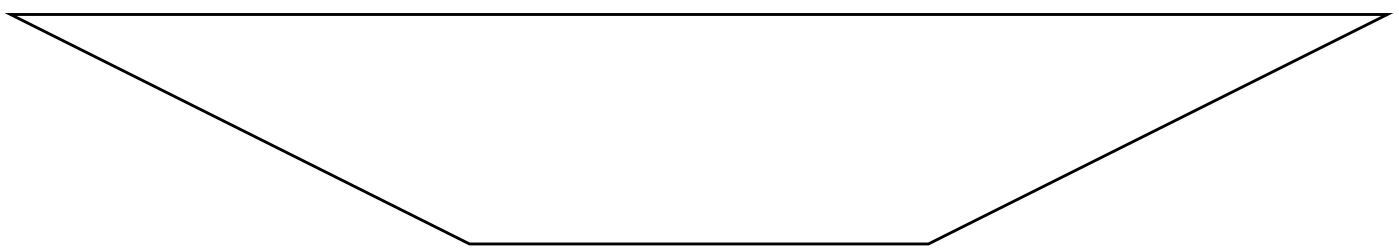


Concrete Beam: Load-to-Failure Experiment

Experimental Setup

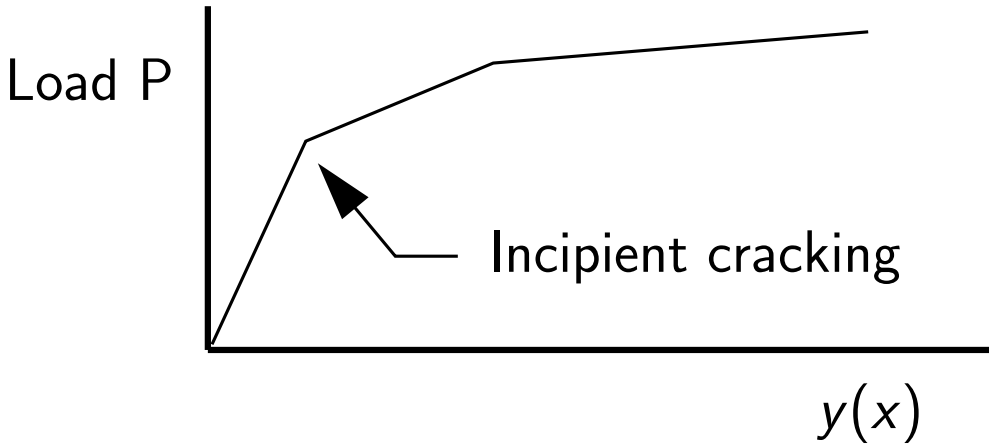


Bending Moment Diagram (BMD)

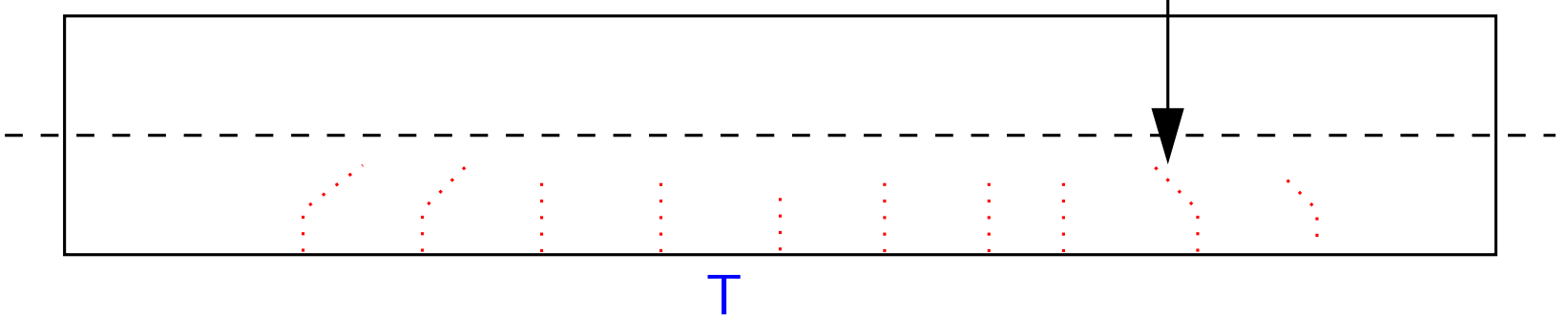


Concrete Beam: Load-to-Failure Experiment

Applied Load P versus Midspan Deflection



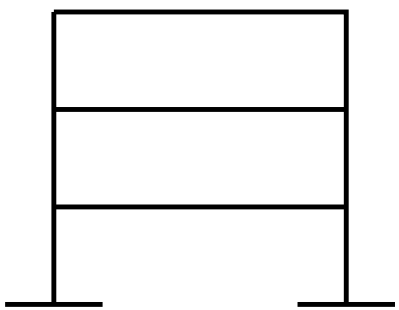
Patterns of Cracking



Direction of cracking perpendicular to slope of BMD.

Pathway from Mechanics to System-Level Behavior

From material-level mechanics to building-system response:

Material Response	integrate →	Section Response	integrate →	Beam Response	assemble →	Building System Response
Stress $\sigma(x, y)$ Strain $\epsilon(x, y)$		Curvature $\phi(x) = \left[\frac{M(x)}{EI}\right]$		Deflection $y(x)$ Slope dy/dx		

How will the integration work?

- Analytical Procedures: The math needs to be "nice" ...
- Numerical Proedures: Compute approximate solutions $\rightarrow$ linear algebra, numerical algorithms, structural analysis and finite elements.