

# Introduction to Structural Mechanics

Section de Génie Mécanique: ME 104  
Spring 2025



## ME-104 Teaching staff:

### Lectures & Lead instructors of the course:



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Prof. Sangwoo Kim

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Maxime Tourne



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Léo Durand



Lucie Tournier



Barbara Zilm



Milena



Markovic Raphaël Javary

# Logistics:

	Monday	Tuesday	Wednesday	Thursday	Friday
10h15					
11h15					
13h15					
14h15	Lecture		Studio	Lecture	
15h00	Lecture		Studio	Lecture	Office hours
	Office hours				

- **'Office' hours:** Right after lecturers or by appointment.

- **Practice Quizzes (not for grade):**

1<sup>st</sup> Quiz

Wed., 12/03/2025: 13h15-14h15

2<sup>nd</sup> Quiz

Wed., 30/04/2025: 13h15-14h15

Studios (Exercise classes)

Wednesdays: CM11/CM13/CM14

- **Assessment method:** Final exam (100%)

Final exams period

During regular studios but in mock exam conditions.

- **Language of instruction:** English

- BUT, many of the teaching assistants also speak French.
- Feel free to ask questions in either English or French. (answers in French during Quizzes/Exam are fine)
- Whenever possible, I'll try to provide English/French word for main concepts, e.g. *Buckling* (fr.: *flambage*)

## Lectures

Mondays: STCC Cloud C (14/4 & 26/5 in CE1-6)

Thursdays: SG1

- \* Presentation of fundamental content
- \* Sample example problems
- \* Practical demonstrations & experiments
- \* Engineering applications & context
- \* Hybrid offering in Zoom (but priority for in-class)
- Zoom link on Moodle.

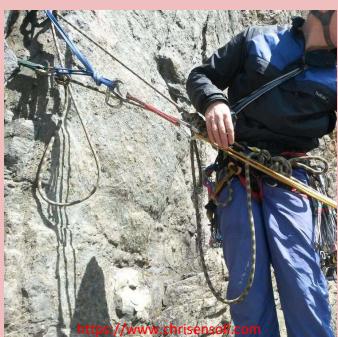
Studios (Exercise classes)

Wednesdays: CM11/CM13/CM14

- \* Reviews and trailers of lecture content
- \* Pencil/paper exercises

## Introduction to Structural Mechanics - Topics

### Part I



<https://www.chrisensoff.com>

**Statics:  
System of Forces**

### Part II



**Static  
Structures**

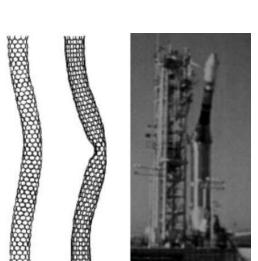
### Part III



<http://www.bamboo-board.com>

**Deformation  
of Elastic Structures**

### Part IV



**Structural  
Failure**

# ME-104 Introduction to Structural Mechanics



## Part I : System of forces

L2: Truss & Beam Structures

L3: System of forces

L4/5: Equilibrium in 2D

L6: Constraints/Determinacy

L7: Equilibrium in 3D

Practice Quiz 1 (during studio)  
12/03/2024



## Part II : Rigid Structures

L8: Structures, Mechanisms

L9/10: Trusses, Frames & Machines

L11: Distributed Forces

L12/13: Beams

L14: Non-straight beams

L15/16: Virtual work

L17: Stability of Equilibrium states



## Part III: Elastic Deformation

L18: Axial loading (1D)

L19: Deformable Structures I

Practice Quiz 2 (during studio)  
30/04/2024

L20: Deformable Structures II

L21: Stress, Strain (>1D)

L22: Elasticity

L23/24: Beam Bending

## Part IV: Structural Failure

L25/26: Elastic failure (Buckling)

**Disclaimer:** This plan is indicative  
(minor changes may be implemented during the semester).

**Studios**  
=   
**Exercise Classes**

Studio 1:	Math revision - vectors
Studio 2:	Systems of forces in 2D
Studio 3:	Equilibrium exercises in 2D
Quiz 1:	Practice Quiz 1 (March 12 <sup>th</sup> )
Studio 4:	Statical determinacy and Equilibrium in 3D, Truss calculations
Studio 5:	Centroids and distributed forces
Studio 6:	Beams
Studio 7:	Frames and Arches
Studio 8:	Virtual work
Quiz 2:	Practice Quiz 2 (April 30 <sup>st</sup> )
Studio 9:	Deformable bodies
Studio 10:	Stresses and recap
Studio 11:	Beams bending, Superposition, Buckling
Studio 12:	Review session: Past exams

**Disclaimer:** This plan is indicative (minor changes may be implemented during the semester).

# **ME-104 Main Learning objectives:**

- 1** Understand the nature of static forces and moments, as well as their balance on loaded structures.
- 2** Recognize and analyze structural elements that compose simple structures (bars, cables, trusses, beams) toward predicting their mechanical performance.
- 3** Understand how the combination of force/moment balance, constitutive relation, and compatibility conditions can be used to determine the deformation and internal loads of a structure.
- 4** Gain introductory knowledge on the concepts of stress, strain and how they are connected through a constitutive law (with a focus on 2D linear elasticity).
- 5** Recognize the limits of elastic deformation and understand the basis of the onset of inelastic deformation, with a focus on elastic buckling.
- 6** Recognize how introductory structural mechanics concepts fit in the broader context of more advanced topics in the mechanics of solids and structures.

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SEARCH + ADD NEW  PEDRO M. NUNES PEREIRA DE ALMEIDA REIS 

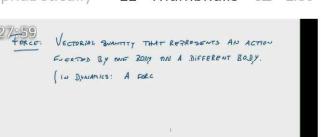
<https://mediaspace.epfl.ch/>

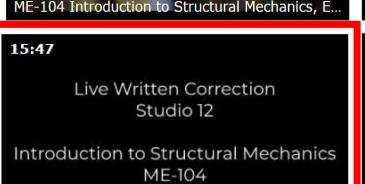
(link to subscribe on Moodle)

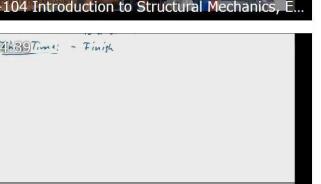
Videos of the live lectures

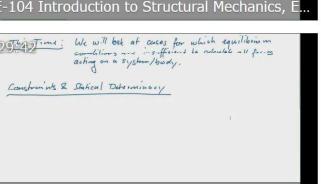
1:12:47  Lecture 1 - Introduction  
ME-104 Introduction to Structural Mechanics, E...

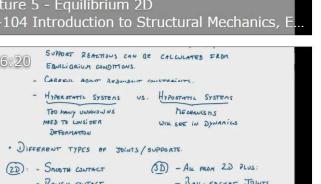
1:23:12  Introduction to Structural Mechanics  
Section de Génie Mécanique: ME 104  
Lecture 2

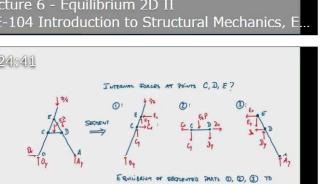
1:27:59  Forces: VECTORIAL QUANTITY THAT REPRESENTS AN ACTION EXERTED BY ONE BODY ON A DIFFERENT BODY.  
(in Dynamics: A force)  
Lecture 3 - System of Forces in 2D  
ME-104 Introduction to Structural Mechanics, E...

15:47  Live Written Correction  
Studio 12  
Introduction to Structural Mechanics  
ME-104  
Studio 12 - Written Correction

1:24:58  Time: We will look at cases for which equilibrium conditions are not sufficient to determine all the forces in a system.   
Lecture 5 - Equilibrium 2D  
ME-104 Introduction to Structural Mechanics, E...

1:26:20  SUDDED REACTIONS CAN BE CALCULATED FROM EQUILIBRIUM CONDITIONS.  
- CARDS AGAIN AGAINST REACTIONS.  
- HYDROSTATIC SYSTEMS VS. HYDRODYNAMIC SYSTEMS  
THE MASS UNBALANCE NEED TO UNDERSTAND DYNAMICS  
- DIFFERENT TYPES OF JOINTS/SUPPORTS  
② - SLIDE CONTACT  
- ROUGH CONTACT  
- PLATES  
- FRICTION  
③ - AN FROM 2D PLUS:  
- 3D: SLICER JOINTS  
- TRUSS EXERCISE (P10)  
Lecture 6 - Equilibrium 2D II  
ME-104 Introduction to Structural Mechanics, E...

1:24:41  Internal Forces at Points C, D, E?  
Lecture 8 - Internal Forces  
ME-104 Introduction to Structural Mechanics, E...

1:24:41  Equilibrium of structures points ①, ②, ③ to determine C, G, D, E, L, T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>  
Lecture 9 - Trusses  
ME-104 Introduction to Structural Mechanics, E...

# Lecture notes:

(Posted on Moodle, the day of the lecture)

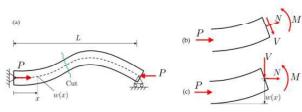


**Lecture 26: Beam Buckling II**

**L26.1 Beam buckling**

We now expand the beam theory that we developed in the past two lectures in a way that permits a compressive load, while assuming no compressive deformation (all motion is still just due to bending).

Considered the following beam (left) of length  $L$  onto which we apply an axial load  $P$ , which we segment to inquire about the internal at the cross section (right): the shear force,  $V(x)$ , normal forces,  $N(x)$ , and moment,  $M(x)$ .



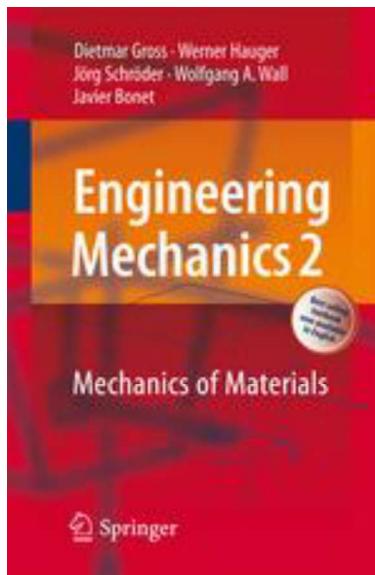
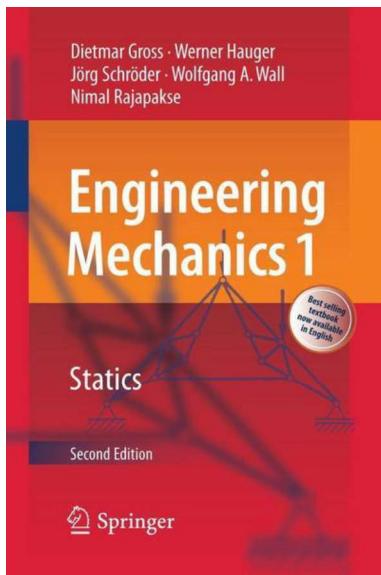
Since the deformations are small, we assume that  $V(x)$  is along  $x$  and that  $N(x)$  is along  $x$ . The deflection of the beam is referred to as  $w(x)$ . Invoking equilibrium, we have:

$$\begin{aligned} \sum F_x &= 0 \quad \Rightarrow \quad P + N = 0 \quad \Rightarrow \quad N = -P \\ \sum F_y &= 0 \quad \Rightarrow \quad V = 0 \\ \sum M &= 0 \quad \Rightarrow \quad M - w(x)N - x.N(x) \quad \Rightarrow \quad M = -P.w(x) \end{aligned}$$

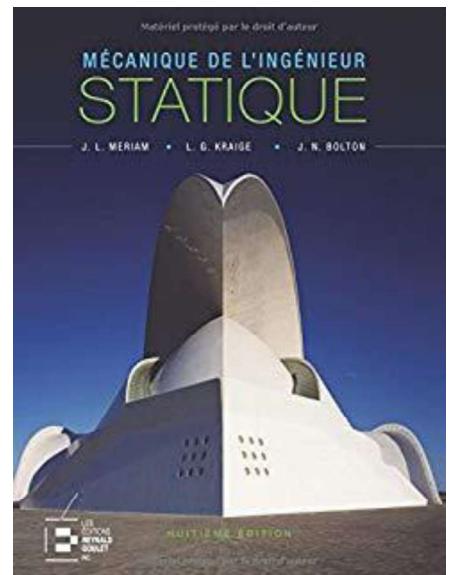
Therefore, the moment-curvature relation reads

$$EI \frac{d^2w}{dx^2} = M = -P.w \quad \Rightarrow \quad EI \frac{d^2w}{dx^2} + P.w = 0$$

## Official Course books



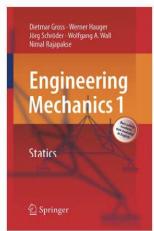
**(in french)**



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Springer Link



## Engineering Mechanics 1

Statics

Authors [\(view affiliations\)](#)

Nimal Rajapakse, Dietmar Gross, Werner Hauger, Jörg Schröder, Wolfgang A. Wall

Textbook

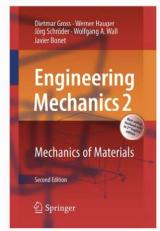
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Springer Link



## Engineering Mechanics 2

Mechanics of Materials

Authors [\(view affiliations\)](#)

Dietmar Gross, Werner Hauger, Jörg Schröder, Wolfgang A. Wall, Javier Bonet

Textbook

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engineering mechanics 1 springer



<https://moodle.epfl.ch/>

ME-104

- Participants
- Grades
- General
  - 17 February - 23 February
  - 24 February - 1 March
  - 2 March - 8 March
  - 9 March - 15 March
  - 16 March - 22 March
  - 23 March - 29 March
  - 30 March - 5 April
  - 6 April - 12 April

Official portal to make announcements and post materials such as lecture notes, exercises, practice problems, etc.

<https://edstem.org/eu/courses/2047>

ed ME-104 - Ed Discussion

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