Mini-project 2
Design of a 2d truss bridge

Project organization:

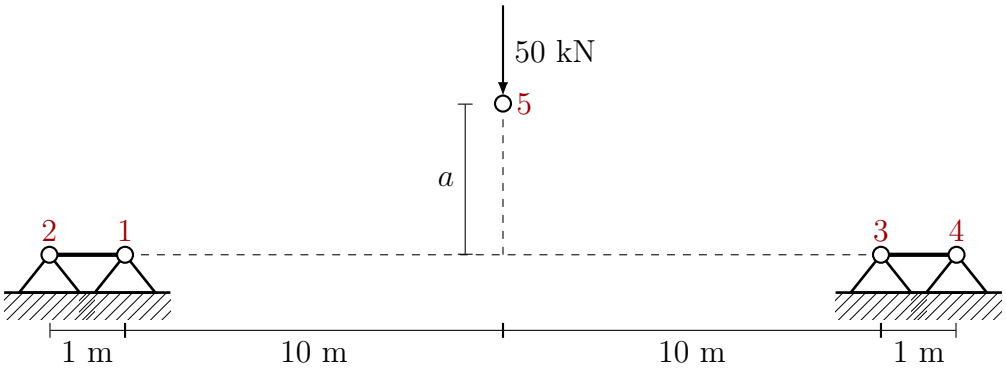
- Groups: 3 to 5 students
- 10% of final grade
- Pdf report: maximum 10 pages
- Programming language: `MATLAB`
- Submission: April 17, 2025
- Total workload: 32h (approx. 8h per student)

You are tasked with designing and analyzing a 2d truss bridge using four fixed anchor points. The bridge must span a 20 meter gap and support a vertical point load applied at the center of the span.

Anchor points and load configuration

The bridge connects the following four supports on a horizontal plane:

- Left outer: (–1, 0)
- Left inner: (0, 0)
- Right inner: (20, 0)
- Right outer: (21, 0)



Truss design requirements

The bridge must be modeled as a 2d truss. All joints are idealized as frictionless pinned connections, meaning no moments are transferred between members. A vertical point load of 50 kN is applied at node 5, located at a defined height a, that can be choosen freely.
You are required both to perform both a static and a dynamic analysis for each of the three materials listed below, treating each case as a distinct full-bridge design. A distinct truss design must be developed for each of these three materials.

Material	E (GPa)	Density (kg/m^3)	Cross-Sectional Area
Structural steel	200	7850	15–50 cm^2
Aluminum alloy	69	2700	20–70 cm^2
Engineered wood	12	600	30–100 cm^2

Static analysis

Each bridge design must strictly adhere to realistic structural behavior by ensuring static performance under load. This means the following two requirements must be satisfied:

1. The entire structure must remain fully within the elastic range of the chosen material—no yielding or permanent deformation is allowed. Additionally, the displacement at any node must not exceed **40 mm**, in accordance with the L/500 criterion.

2. Your design should aim to optimize the total material volume. The total volume of the structure must not exceed the specified limit:

   - Structural steel: **1 m^3**,
   - Aluminum alloy: **1.7 m^3**,
   - Engineered wood: **2 m^3**.

Dynamic analysis

A separate modal analysis must be performed for each of the three trusses corresponding to the different materials. The following requirement must be satisfied:

3. For each design, compute the first three natural frequencies and the corresponding mode shapes. The first natural frequency must *not* fall within the range of **1.5 to 10 Hz**.

Bonus: To ensure dynamic stability and avoid resonance with common excitation sources, you should aim for a first natural frequency **above 50 Hz**, where feasible.

Deliverables

1. `MATLAB:`

   - Nodes and elements definitions
   - Stiffness and mass matrices assembly
   - Static and modal analysis
   - Plots and visualizations

2. **Report:**

   - Truss layouts with labeled pins and bars,
   - Summary of `MATLAB` results (displacements, stresses, frequencies and mode shapes),
   - Discussion of your findings.