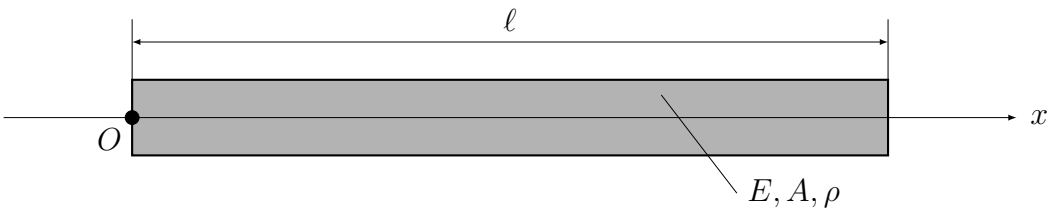
Mini-project 1
Natural frequencies and mode shapes of a uniform bar

Project organization:

- Groups: 3 to 5 students
- 10% of final grade
- Pdf report: maximum 10 pages
- Programming language: `MATLAB`
- Submission: March 21, 2025
- Total workload: 32h (approx. 8h per student)



a) Model, using n finite elements and the local approach, a bar of length $\ell = 1$ m, uniform cross-section $A = 0.01$ m^2, elasticity modulus $E = 210$ GPa, and mass density $\rho = 7850$ kg/m^3 under the following conditions:

- **Group A**: quadratic finite elements, free-free boundaries
- **Group B**: quadratic finite elements, clamped at $x = 0$, free at $x = \ell$
- **Group C**: quadratic finite elements, clamped at $x = 0$ and $x = \ell$
- **Group D**: cubic finite elements, free-free boundaries
- **Group E**: cubic finite elements, clamped at $x = 0$, free at $x = \ell$
- **Group F**: cubic finite elements, clamped at $x = 0$ and $x = \ell$

b) Determine the approximate natural frequencies and approximate mode shapes of the bar for $n = 1, 2, 4, 8$ and 16 finite elements.

c) Compare the results with the exact natural frequencies obtained from analytical solutions and analyze the convergence of the numerical predictions.