Department of Mechanical and Aeronautical Engineering

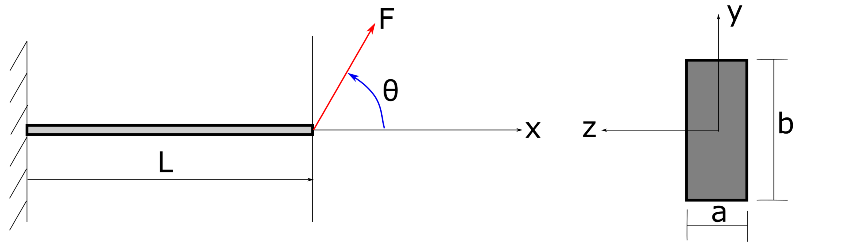
Simulation-based design MOW 323

Exercises - Week 1

August 19, 2021

1 Exercise 1

Consider the following beam, with $E = 200$ GPa, $L = 1$m, $F = 100$N, $\theta = \frac{\pi}{4}$rad, $a = 10$mm and $b = 20$mm.



(a) Calculate the stiffness for the case where a horizontal displacement is measured at $x = L$ and a horizontal force is applied at $x = L$.

(b) Calculate the stiffness for the case where a vertical displacement is measured at $x = L$ and a vertical force is applied at $x = L$.

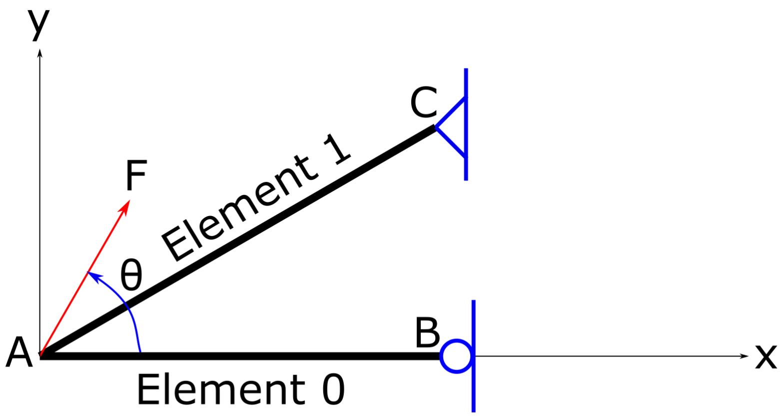
(c) Plot the internal axial force and bending moment as a function of x.

(d) Calculate the maximum stress in the beam. Where is this located?

2 Exercise 2

This problem has to be performed in python.

Consider the following system:



$F = 100\text{N}$ and $0 \leq \theta \leq 2\pi$ rad. The coordinates of the nodes are given by:

A	0 m	0 m
B	1 m	0 m
C	1 m	1 m

Both elements have a cross sectional area of 100mm^2

(a) Draw a free body diagram of the system.

(b) Plot the force in the members as a function of θ.

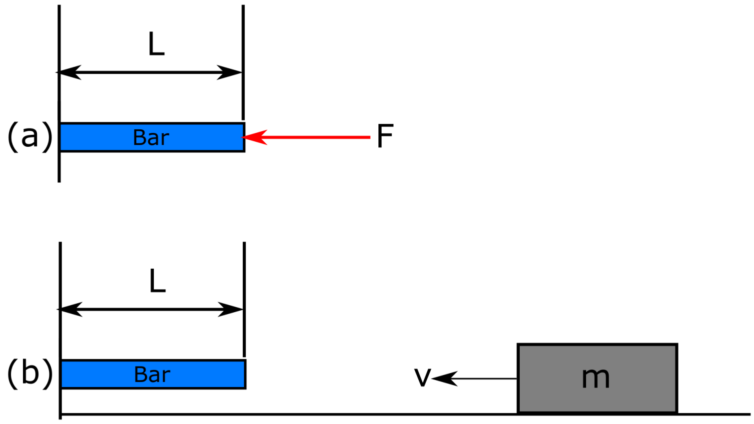
(c) Plot the stress in the members as a function of θ.

(d) At which force angle θ is element 0 most susceptible to buckling?

3 Exercise 3

This problem has to be performed in python.

Consider the following problem:



There are two cases: (a) A static case where a force of $F = 20$kN is slowly applied. (b) A case where a mass impacts the bar. Assume that the mass remains in contact with the bar and that there is no friction.

The bar is made out of the following material:

- Young's modulus: $E = 200$ GPa.
- Yield strength: $S_y = 300$ MPa.

The bar has a square cross section with a side length of 0.1.

Q1: For case (a), use $L = 1$m

- Draw a free body diagram of the problem.
- Calculate the maximum displacement of the bar.
- Calculate the maximum stress in the bar.
- Calculate the safety factor against yielding.
- Calculate the safety factor against buckling.
- Calculate the overall safety factor (combining the influence of buckling and yielding).

Q2: For case (b), use $L = 1$m, $m = 1$kg, $v = 1$m/s

- Draw a free body diagram of the problem for the maximum displacement case.
- Calculate the maximum displacement of the bar.
- Calculate the maximum force in the bar.

- Calculate the maximum stress in the bar.
- Calculate the safety factor against yielding.
- Calculate the safety factor against buckling.
- Calculate the overall safety factor.

Hint: If you use the code from Q1, you can just change the force to calculate the answers for this question.

Q3: Plot the safety factor of the beam against yielding for different lengths $0.1 \leq L \leq 3$m and two different materials.

- $E = 200$ GPa, $S_y = 300$ MPa
- $E = 70$ GPa, $S_y = 160$ MPa

Both load cases are under consideration and $m = 1$kg, $v = 1$m/s.

Hint: Use L on the x-axis, the safety factor on the y-axis and include the two different materials as two different lines.

Q4: Plot the overall safety factor of the beam for different lengths $0.1 \leq L \leq 3$m and two different materials.

- $E = 200$ GPa, $S_y = 300$ MPa (Yield)
- $E = 70$ GPa, $S_y = 160$ MPa (Yield)

Both load cases are under consideration and $m = 1$kg, $v = 1$m/s.

Hint: Use L on the x-axis, the safety factor on the y-axis and include the two different materials as two different lines.

Q5:

- Reflect on the influence of the load case on the safety factors.
- Reflect on the influence of the yield strength on the safety factors.
- Reflect on the influence of the Young's modulus on the safety factors.