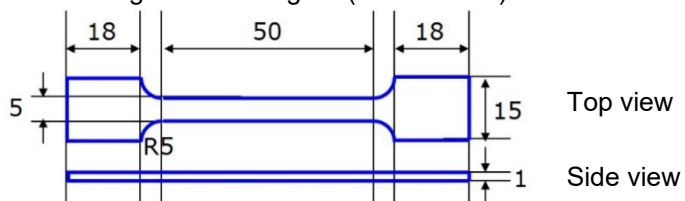


Lesson 05: Mechanical testing

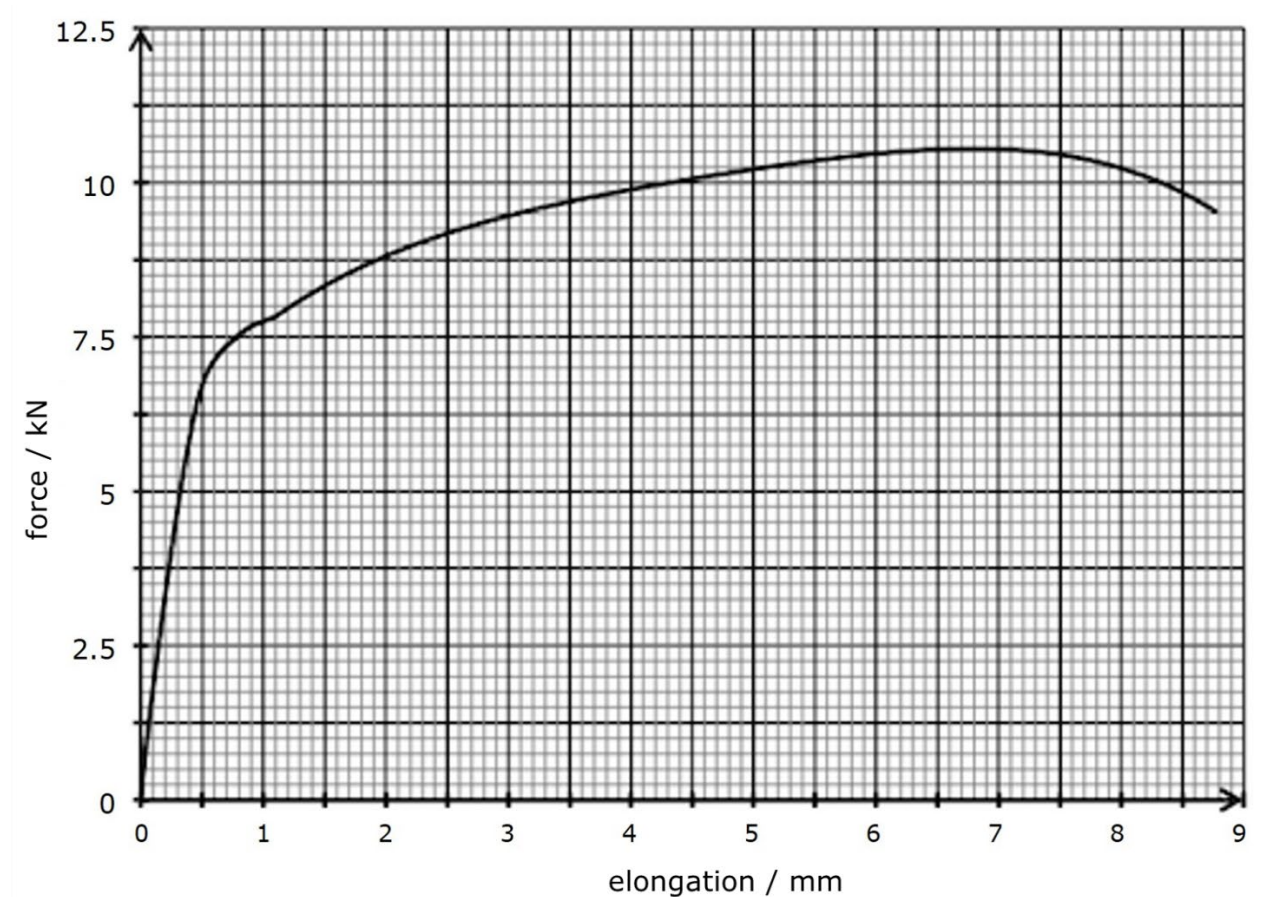
Exercise 05.1: Tensile testing

A flat dog bone-shaped specimen made of the metal unobtainium is tested in tension. The sizes are given in the figure (in millimeter).



The required force to pull on the specimen is measured in dependence on elongation until fracture as seen from the figure.

How does the flow curve in a stress strain diagram look like? Change the axis to obtain such a stress strain diagram.



Determine characteristic mechanical properties from the flow curve.

- 1) Young's modulus.
- 2) Proportional limit
- 3) Stress at 0.2-limit
- 4) Tensile strength
- 5) Fracture strength
- 6) Largest elastic strain before plastic yielding
- 7) Largest elastic strain during entire test
- 8) Maximal strain before fracture
- 9) Resilience (area under flow curve in elastic region)

Exercise 05.2: Beverage can use ANSYS GRANTA EduPack
(if you feel uncomfortable to jumpstart, work through the intro exercises first)

1. Find from the hundred materials of Level 2 in CES, the ones mentioned as used for cans by searching for 'beverage can'. What material could be found on the internet for 'beverage can'?
2. The total price for a can is $V\rho p$. Create a chart showing (mass) density ρ and kilogram price p .
3. If the volume V of the can material is fixed, the relevant parameter becomes ρp . Create a chart with this parameter on the vertical axis and the hundred materials listed on the horizontal axis. Sort them after materials classes by using 'advanced' settings.
4. Using a material for beverage cans requires more restrictions. Use the 'limit' function for choosing materials which are 'excellent' with respect to their 'durability in aqua and aqueous solutions' and 'excellent', 'acceptable' or at least of 'limited use' for durability with alcohol.
5. Finally, the can should not break when dropped on the floor. This is quantified by the fracture toughness which should be at least $3 \cdot 10^6 \text{ Pa} \cdot \text{m}^{1/2}$.
6. How many materials are left? Which materials (for the individual materials classes) would be cheapest to make cans?



Exercise 05.3: Stiff and lightweight rod

A round rod with a length of 2 m should be manufactured from a metal (Fe, W, Ni, Al, Mg or Ti). It must not extend more than 2 mm when loaded with a mass of 2 t.

- (a) Which is the minimum diameter required for each metal?

Use the material parameters from table 6.1 in the book.

- (b) Which metal should be selected for a rod as light as possible? Which is the relevant parameter?

The mass density can be found in appendix B.

- (b) Which metal should be selected for a rod as cheap as possible? Which is the relevant parameter?

The price can be found in ANSYS GRANTA EduPack.