

FINALE 2021-LuxPhO

EXPERIMENT

BENDING OF A THIN SAW BLADE:

ELASTIC ENERGY OF A THIN ROD.

DETERMINATION OF THE ELASTIC MODULUS OF STEEL.

Explanations

Materials:

- 1 x metal saw blade
- 1x table clamp
- 1 x 1m ruler with millimeter scale in base with 2 arrow marks
- 1 x set square
- 1 x set of masses (10 g and 1 g)
- 1 x pair of scissors
- 1 x envelope with cord
- 1 x caliper
- 1 x micrometer screw
- 3 x sheets of graphing paper size A4

ALL MEASURED VALUES MUST BE CLEARLY INDICATED.

Experiment 1.

If a thin rod is clamped and loaded with mass pieces at one end, it bends and is displaced by s from its starting position.

The rod is clamped to a tabletop at one end. The deflection s is measured for increasing vertical loads F ($0\text{ N} < F < 1\text{ N}$) at the free end (Fig. 1.)

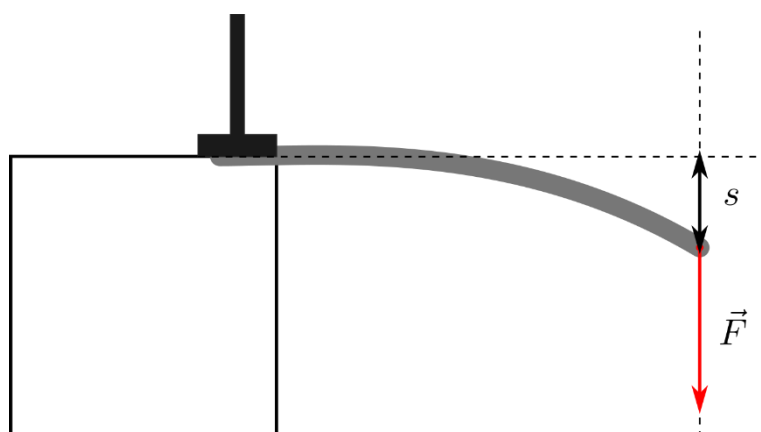


Figure 1 - Side View

1. Graph the deflection s as a function of the load F . Estimate the measurement error of the deflection and add it to the graph.
2. Briefly comment on what you observe on the graph.
3. Represent the elastic energy stored in the rod as a function of deflection. Use the graph and explain your approach. $s - F$

In solid state theory, the formula for deflecting a rod by s is:

$$s = 4 \cdot \frac{\ell^3}{E \cdot b \cdot d^3} \cdot F$$

ℓ = Length of rod

b = Width of the rod

d = thickness of the rod

E = modulus of elasticity of the rod material

This formula applies to small deflections, where the load acts vertically. In fact, the bending of the rod is caused by the torque of the applied force F so that you should consider only normal component of the force F_{\perp} (Fig. 2) as contributing to the bending.

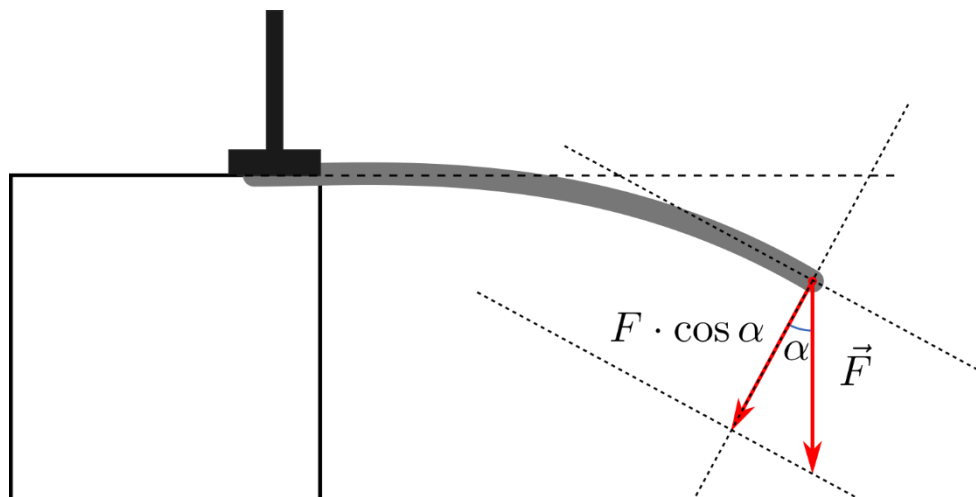


Figure 2 - Component that contributes to the bend.

Experiment 2.

4. Perform the required measurements for the loads $0 \text{ N} < F < 1 \text{ N}$ to show that $F \cdot \cos \alpha$ is proportional to s . Graph the force as a function of the deflection including measurement errors of the deflection. Consider how you want to include the initial state of the rod before any load is applied and explain your procedure.
5. From your results, determine the elastic modulus of the steel. The table value for steel is approximately $20 \cdot 10^6 \text{ N/cm}^2$. Calculate the relative error of your value E .
6. Explain the largest source of measurement errors.

Measurement table: Experiment 1

Load F	Deflection s	Elastic energy

Description of the graph:

Explain how you calculate the Energy:

Measurement: Experiment 2

Load F	Angle α	Deflection s		

- $\ell =$
- $b =$
- $d =$

Investigation for E:

Influence of sources of error