Mechanics of deformable bodies
COE – 3001
Strength of materials
Homework #1

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Modeling assumptions

Unless otherwise stated, the following assumptions of strength of materials are adopted throughout this assignment:

- material is continuous, homogeneous, and isotropic,
- deformations are small,
- linear elastic behavior,
- loads and supports are perfectly idealized.

Exercise I Questions on the course

Do you feel confident about your knowledge of the course? Please answer each question to assess your understanding.

1. Mechanics calculations must always be performed using consistent units.

☐ True ☐ False

2. Numerical results can still be correct if unit consistency is violated.

☐ True ☐ False

3. A force is fully defined by its magnitude and direction only.

☐ True ☐ False

4. A force is a vector defined by magnitude, direction, orientation, and point of application.

☐ True ☐ False

5. Forces and moments can be combined into a single mechanical representation.

☐ True ☐ False

6. Strength and stiffness describe the same mechanical property.

☐ True ☐ False

7. Stiffness characterizes resistance to deformation.

☐ True ☐ False

8. A structure can be stiff but fail at a relatively low load.

☐ True ☐ False

9. Stability is related to sudden changes of shape such as buckling.

☐ True ☐ False

10. Continuity assumes that matter is treated as a continuous medium.

☐ True ☐ False

11. Homogeneity means that material properties vary with position.

☐ True ☐ False

12. Isotropy means that material properties depend on direction.

☐ True ☐ False

13. The assumptions of strength of materials are always perfectly satisfied in real materials.

☐ True ☐ False

14. The validity of these assumptions depends on the observation scale.

☐ True ☐ False

15. Elastic deformation is reversible after unloading.

☐ True ☐ False

16. Plastic deformation leads to permanent shape change.

☐ True ☐ False

17. Plastic deformation in crystalline materials is mainly due to dislocation motion.

☐ True ☐ False

18. Removing the load always restores the initial geometry.

☐ True ☐ False

19. Mechanical equilibrium requires force equilibrium only.

☐ True ☐ False

20. A rigid body in equilibrium satisfies both force and moment equilibrium.

☐ True ☐ False

21. Reaction forces appear only where degrees of freedom are constrained.

☐ True ☐ False

22. A fixed support blocks all translations and rotations in three dimensions.

☐ True ☐ False

23. A free body diagram must include all external forces and reactions.

☐ True ☐ False

24. Internal forces appear when a structure is cut for analysis.

☐ True ☐ False

25. Large variations of internal loads indicate critical zones in a structure.

☐ True ☐ False

26. Stress is a force.

☐ True ☐ False

27. Stress is the response of a material to applied loads.

☐ True ☐ False

28. Stress depends on both loading and geometry.

☐ True ☐ False

29. Stress is directly measured in kilograms.

☐ True ☐ False

30. Allowable stress is used in design to avoid unexpected failure.

☐ True ☐ False

Exercise II Axial stress

A solid cylindrical bar with a diameter of 100 mm and a length of 1 m is subjected to a uniaxial tensile force of 30 kN, applied normal to its cross-section.

1. Determine the normal stress σ acting on the cross-section of the bar.
2. Comment on the order of magnitude of the obtained stress. Is it low or high compared to typical allowable stresses for metallic materials?

Exercise III Shear stress

A solid cylindrical bar with a diameter of 20 mm and a length of 1 m is subjected to shear forces of 200 N, as shown in Figure 1.

1. Determine the shear stress τ acting on the cross-section of the bar.
2. Verify the dimensional consistency of the expression used to compute the shear stress.

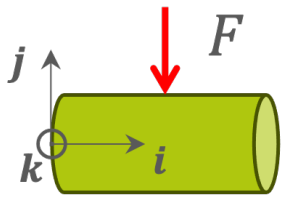

Figure 1: Cylindrical bar subjected to transverse shear forces.

Exercise IV Simply supported beam with a point load

Consider a simply supported beam with (see Figure 2):

- a roller support at A,
- a pin support at B,

subjected to a vertical concentrated force F applied at point C.

The parameters F, a, and b are known.

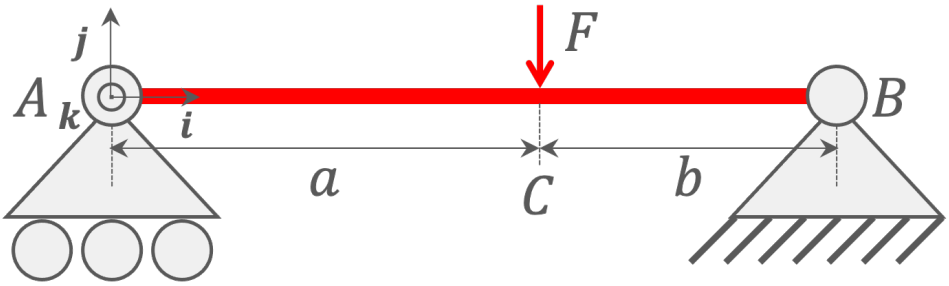

Figure 2: Simply supported beam with a concentrated load applied at point C.

1. Draw the free-body diagram of the beam.
2. Identify the unknown reaction forces.
3. Using the Fundamental Principle of Statics, derive the equations relating the reaction forces to F, a, and b.

4. State whether the beam is statically determinate or statically indeterminate.

5. Determine the expressions of the internal force resultants (axial force, shear force, bending moment) along the beam AB.

6. Does satisfying static equilibrium guarantee that the beam will not fail? Briefly justify your answer.

Exercise V Uniformly loaded beam

A beam is subjected to a uniformly distributed load of intensity P, as shown in Figure 3.

- Pin support at A,
- Roller support at B.

The parameters P, a, and b are known.

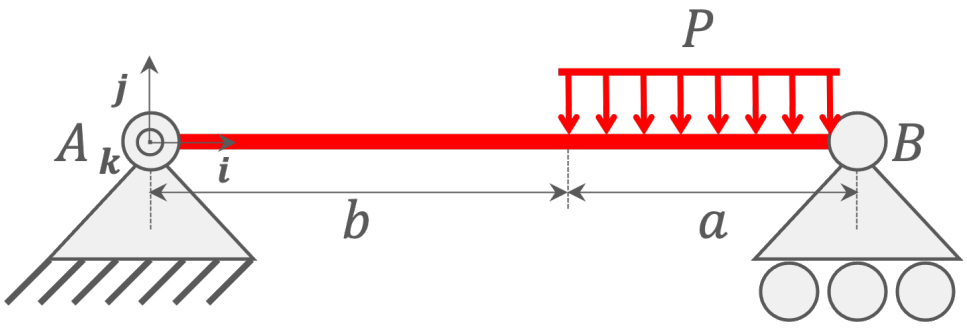

Figure 3: Simply supported beam subjected to a uniformly distributed load.

1. Draw the free-body diagram of the beam.

2. Determine the expressions of the reaction forces in terms of P, a, and b.

3. Based on the reaction forces, comment on the symmetry of the loading and support configuration.

Exercise VI Cantilever beam with combined loading

A cantilever beam, fixed at point A, is subjected to the following loads (see Figure 4):

- a concentrated force F applied at an angle α,
- a uniformly distributed load P applied over a portion of length a of the total beam length L.

Determine the expressions of the reaction forces and reaction moment at the fixed support in terms of a, L, α, P, and F.

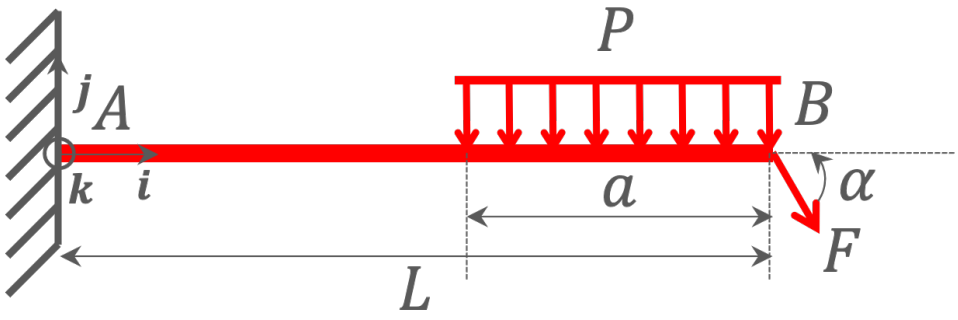

Figure 4: Cantilever beam subjected to combined concentrated and distributed loading.

Exercise VII Beam under self-weight

A beam of length L and total weight P rests on two supports:

- A: pin support,
- B: roller support (frictionless).

The weight P is modeled as a uniformly distributed load of intensity

$$\frac{P}{L}\ \mathrm{N\,m^{-1}},$$

as shown in Figure 5.

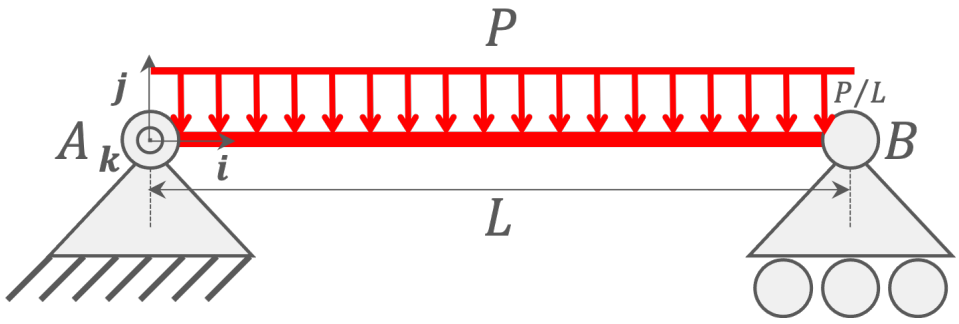

Figure 5: Simply supported beam subjected to its own weight modeled as a distributed load.

1. Derive the equations relating the reaction forces to the parameters of the problem.
2. Determine the expressions of the internal forces (axial force, shear force, bending moment) as functions of P, L, and the position x.
3. Plot the corresponding internal force diagrams.
4. From the bending moment diagram, identify the most critical section of the beam. Where would a flexural failure most likely initiate?

Exercise VIII Beam with applied bending moment

A beam of length L is subjected to an applied bending moment M at point B, as shown in Figure 6.

- Fixed support at A,
- Roller support at C.

The parameters M, a, and L are known.

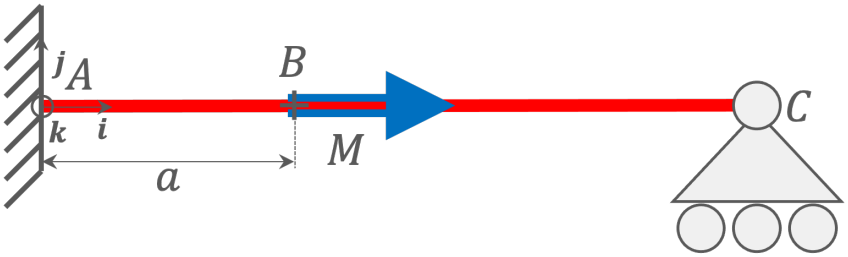

Figure 6: Beam subjected to an applied bending moment with mixed boundary conditions.

1. Determine the expressions of the reaction forces and reaction moments as functions of M, a, and L.

2. Would the structure remain statically determinate if the roller support at C were replaced by a fixed support? Explain your reasoning without calculation.