== **Delft University of Technology** ==
University Course Applied Mechanics

Give on the upper right corner of each sheet your
NAME
STUDY NUMBER *and*
DISCIPLINE

Exam STATICS 2003.01.09 / 14.00-17.00

The work of a student who does not fulfill the requirements for taking an exam will not be marked.

Notes

Only hand in the answer sheets.
Any other sheets will not be accepted.

Write your name and study number on every sheet.
Sheets without name and study number will not be accepted.

Write relevant calculations on the answer sheets.
Use the blank sides of the answer sheets if necessary.

Answers without calculation are not taken into account.

Use possible checks in order to avoid calculation errors.
The order of answering the questions is free.
N.B.: **this exam consists of 5 problems.**

The **neatness of the presentation** of the answers
will be considered in the marking.

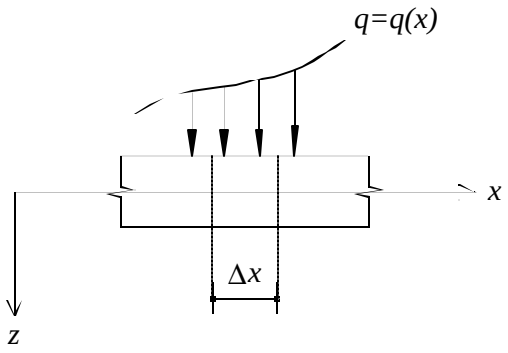
Unless otherwise stated the following holds:

Pulleys, hinged joints and supports with hinges are frictionless.

The weight of the structure is not taken into account.

Problem 1 (weight 1,2 - about 20 minutes)

A beam is loaded perpendicular to its axis by a distributed load $q = q(x)$.

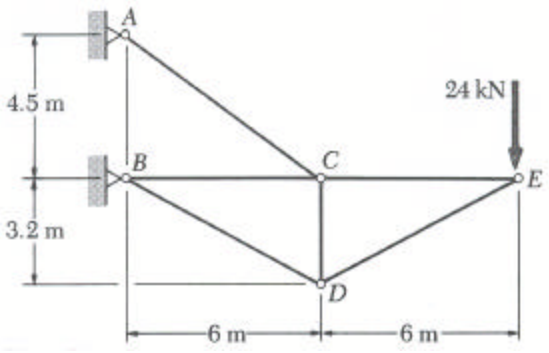


Questions:

a. Sketch the positive internal forces and moments acting on a beam element with an infinitesimal length Δx.
b. Derive the differential equations for the equilibrium of this beam element.
c. Derive (using the previous result) also the relation between the bending moment M in the beam and the distributed load q.

Problem 2 (weight 2,2 - about 35 minutes)

The truss which is represented in the figure including the dimensions, is loaded by a vertical force $F = 24\,\text{kN}$ in E. The maximum load which can be supported by a bar is 200 kN in tension and 130 kN in compression.

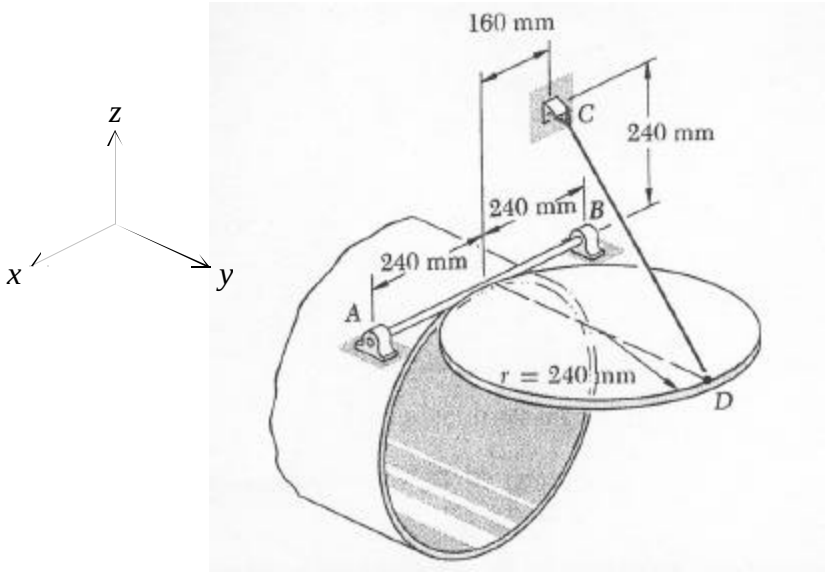


Questions:

a. Determine the horizontal and vertical reaction forces in A and B. In the figure, sketch these forces in the directions in which they act and give their values.
b. Make a check of the reaction forces by stating the moment equilibrium equation of the truss about D.
c. Determine all member forces with the correct signs (tension positive, compression negative).
d. Determine the force polygon belonging to the equilibrium of joint D.
e. Determine the maximum force *F* the truss can support. Which bar/bars is/are critical?

Problem 3 (weight 2,2 - about 45 minutes)

A circular cover of a tube is rigidly attached to axis AB. The radius of the cover is 240 mm, the weight 300 N. The line of action of the weight intersects the center of the cover. The remaining dimensions can be read from the figure. The cover is held in a horizontal position by cable CD. The support in A can sustain a horizontal force in direction AB, while that in B cannot.

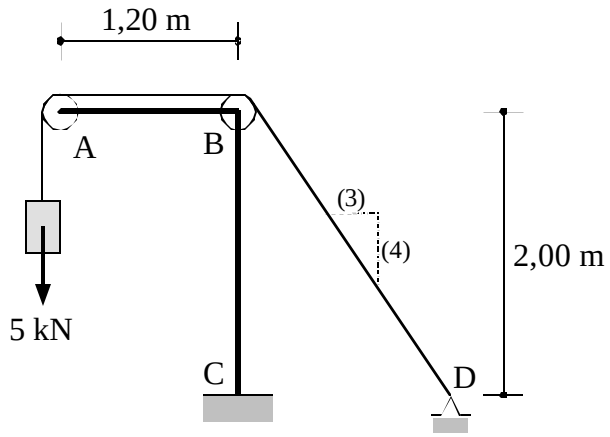


Questions:

a. Determine the force in cable CD.
b. Determine all reaction forces in x-, y- and z-direction. In the figure, sketch these forces in the directions in which they act and give their values.

Problem 4 (weight 2,2 - about 35 minutes)

Frame ABC is clamped in C. AB and BC are perpendicular. Pulleys are attached in A and B to the centerline of frame ABC. A cable is passing over these pulleys. At its free end the cable is loaded by a force of 5 kN. The dimensions can be read from the figure.

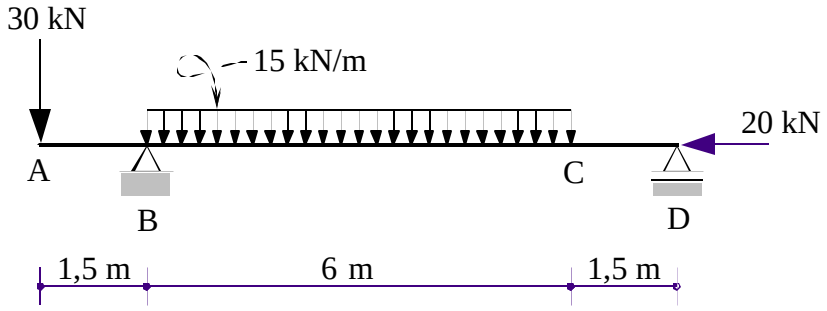


Questions:

a. Determine and sketch in the figure the forces exerted by the cable on the frame.
b. Determine the reaction forces on the frame in C. Sketch these forces in the directions in which they act and give their values.
c. Sketch for ABC the moment and shear force diagram and give their values. Use the deformation signs (or plus and minus sign) in order to clarify the direction in which the moments and shear forces act.
d. Sketch the normal force diagram with the correct signs for tension and compression (tension positive, compression negative) and give their values.

Problem 5 (weight 2,2 - about 45 minutes)

The beam ABCD has a pin support in B and a roller support in D. The beam is loaded by a uniformly distributed load of 15 kN/m on part BC, a vertical force of 30 kN at A and a horizontal force of 20 kN at D. The dimensions can be read from the figure.



Questions:

a. Determine the horizontal and vertical reaction forces. Sketch these forces in the figure in the direction in which they act and give their values.
b. Sketch the normal force diagram with the correct signs (tension positive, compression negative). Give their values.
c. Sketch the moment and shear force diagram and give their values. Clarify by means of the deformation signs (or plus and minus sign) the directions in which the moments and shear forces act. Sketch in B and C the tangents to the moment diagram and show clearly the intersection of these tangents.
d. The bending moment in BD reaches its maximum (absolute) value in cross section E. Determine the location of E.
e. Consider the free-body ED and sketch all forces acting on this part. Give their values.
f. Determine the value of the maximum moment in E.