Delft University of Technology
==== Faculty AE ====
Section Engineering Mechanics

In the upper right corner state
your **NAME**
and **STUDENTNUMBER**

Exam AE1-914-I – Statics

2004.01.16 from 9.00-12.00

If the candidate does not fullfill all requirements for admission to this exam the work will not be graded.

This package contains the complete text of all problems and is to be used to provide all answers.
Separate sheets and scrap paper will not be accepted!

Provide your name and student number in the upper right corner of all sheets.
Sheets without name and student number will not be accepted!

All relevant calculations must be provided.
If necessary, use the blank backside of the sheets.
Answers without any calculation will not be given credit.

Check your answers to avoid errors in your calculations.
Make the problems in an order of your choice.
ATTENTION: **there are 5 problems.**

The **clarity of the presentation** of your results will be
taken into account in the grading process.

PROBLEM 1 (weight 1 - ± 20 min.)   Name:

The drawing below shows a student on a bike viewed from behind. The student carries two crates of beer on the luggage rack of his bike. Additionally it is given that:

- Each crate has a width of 30 cm and a height of 20 cm.
- The luggage rack has a width of 20 cm.
- Each crate weighs 100 N. The weight can be considered to be uniformely distributed over the crate.
- The crates touch each other in one point only.
- Each crate touches the luggage rack in one point only.
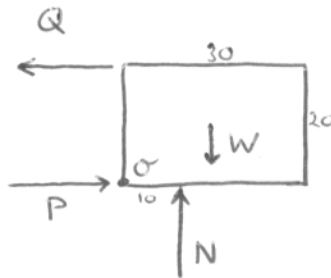
Questions:
a. Draw a free body diagram of one of the crates and draw all forces acting on it. Assume that the student exerts no vertical forces on the crates. Use the space provided to the right of the picture.
b. What is the magnitude of the horizontal force on the hand of the student as a consequence of carrying the crates?

$$+\curvearrowright \Sigma M_{o} : \quad Q \cdot 20 + N \cdot 10 - W \cdot \frac{30}{2} = 0$$

$$\Sigma F_{v} \uparrow^{+} : \quad N - W = 0$$

$$\Sigma F_{h} \rightarrow^{+} : \quad -Q + P = 0$$
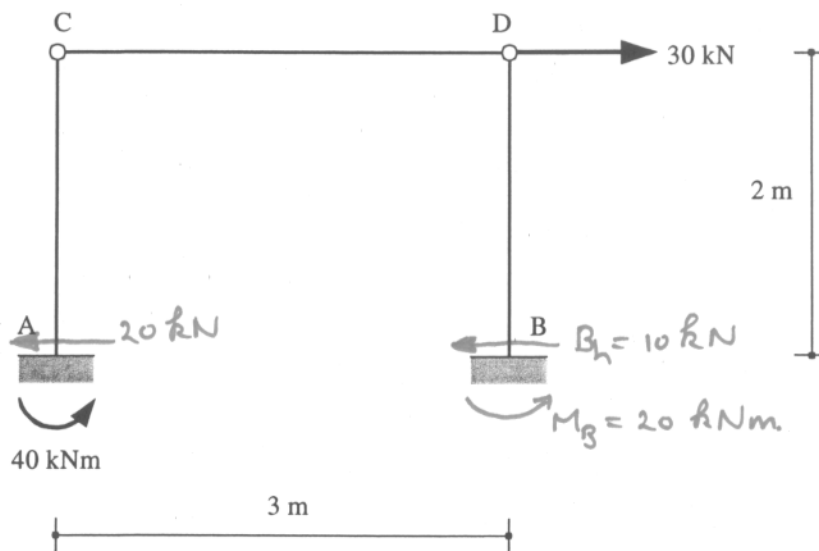
$$\Rightarrow \quad Q = 25 \; N.$$
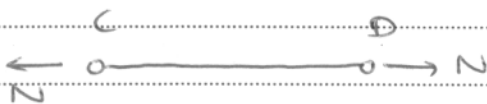
PROBLEM 2 (weight 2,5 - ± 40 min.)   Name:

You are given the statically indeterminate structure drawn below. The magnitude and sense of the moment in A are given.

Question:
a. Calculate all other support reactions. Draw each support reaction in the figure with the correct sense and give the magnitude.

C   D
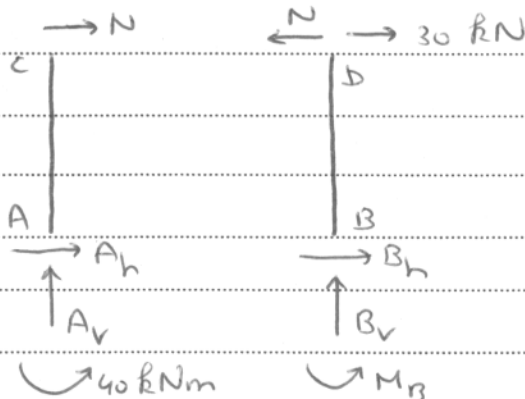   ➤ 30 kN

                                                        │
                                                        2 m
                                                        │

A │ ── 20 kN   B ◄── $B_h = 10 kN$

                                          ↰ $M_B = 20 kNm$

40 kNm

│──────── 3 m ────────│

CD is a two-force member.

C   D
←── o──────o ──→ N
N

→ N   N ← → 30 kN
C   D

│   │
A │   B │
→ A_h → B_h
↑ A_v ↑ B_v
↰ 40 kNm   ↰ M_B

For AC take $\Sigma M_A = 0$
$\Rightarrow 40 - 2N = 0 \Rightarrow N = 20 kN.$

$\Sigma F_h = 0 : A_h = -20 kN$
$\Sigma F_v = 0 : A_v = 0. kN.$

For BD take $\Sigma M_B = 0 :$
$\Rightarrow M_B + 2N - 30 \cdot 2 = 0$
$M_B = 20 kNm.$
$\Sigma F_v = 0 : B_v = 0 kN.$
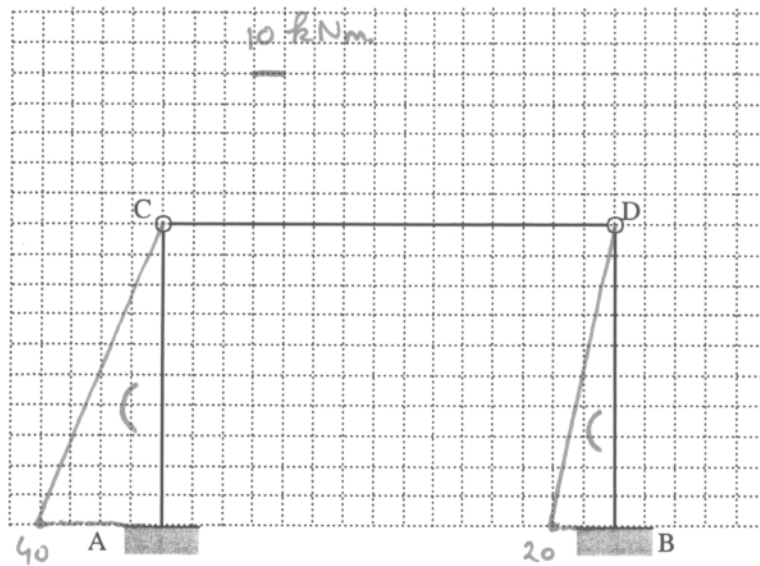$\Sigma F_h = 0 : -N + 30 + B_h = 0$
$B_h = -10 kN$

3

PROBLEM 2 (weight 2,5 - ± 40 min.)   Name:
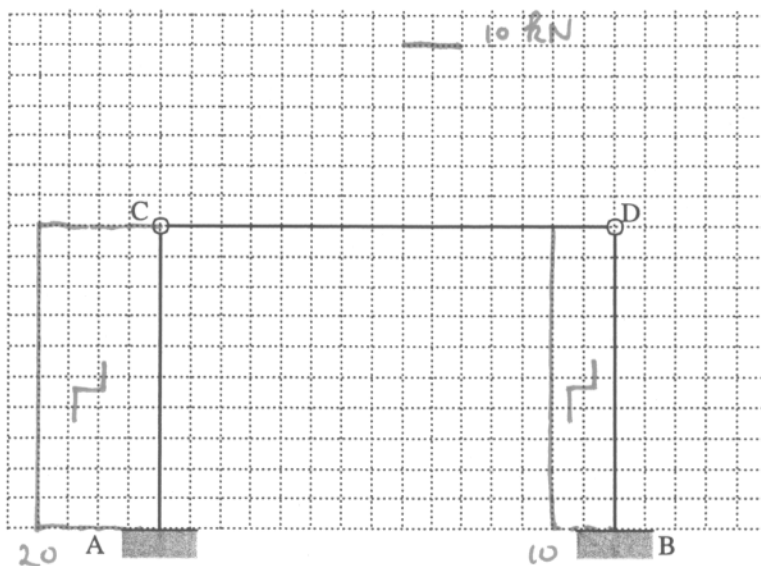
b.   Draw the M-diagram and V-diagram for the entire structure with the deformation signs. Write down the characteristic values.

M-lijn:

V-lijn:
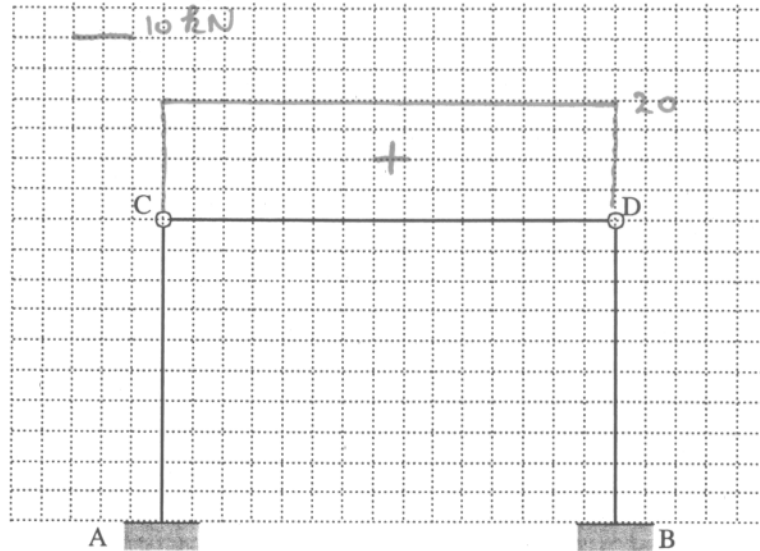
PROBLEM 2 (weight 2,5 - ± 40 min.)   Name:

c.   Draw the N-diagram for the entire structure with the correct signs for tension and
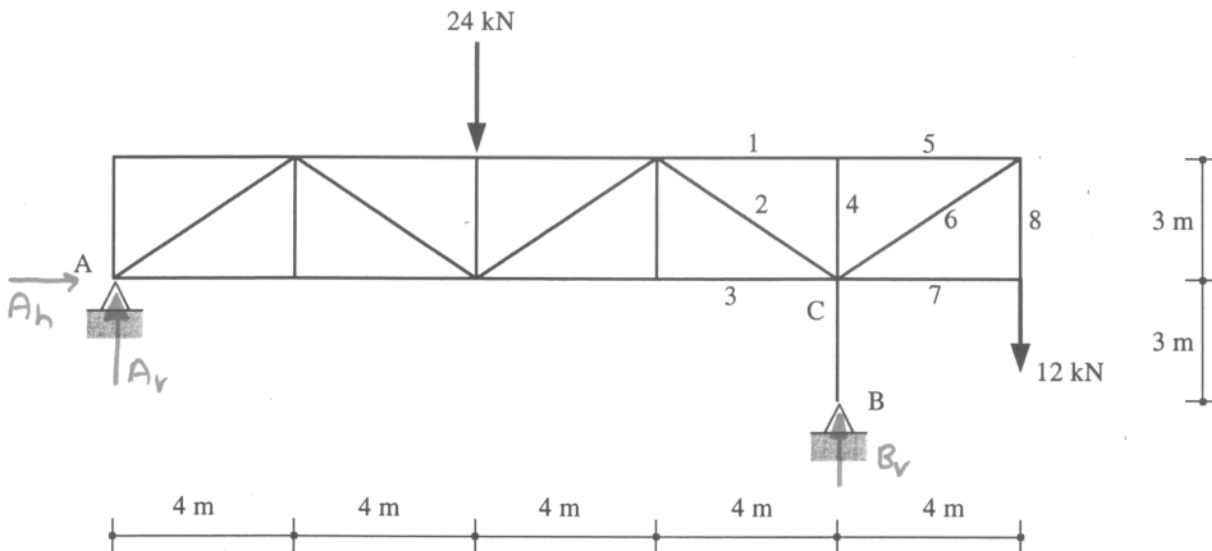   compression. Write down the characteristic values.

N-lijn:

PROBLEM 3 (weight 2,0 - ± 40 min.)   Name:

You are given the following truss structure.

Question:

a. Calculate the support reactions and draw them in the figure with the correct sense.

$B_h = 0$ since BC is a two-force member, $\Rightarrow$ $A_h = 0$.

$\Sigma M_A = 0$: $B_v \cdot 4 \cdot 4 - 24 \cdot 2 \cdot 4 - 12 \cdot 5 \cdot 4 = 0$ $\Rightarrow$ $B_v = 27\ kN$.

$\Sigma F_v = 0$: $A_v + B_v - 24 - 12 = 0$ $\Rightarrow$ $A_v = 9\ kN$

b. Calculate the forces in bars 1 to 8 with the correct signs for tension and compression.

S_7 $\leftarrow$ $\uparrow S_8$ $\Rightarrow$ $S_8 = 12\ kN$

$\downarrow 12\ kN$ $S_7 = 0$.

$S_5 \leftarrow$ $\searrow S_8$ $\nwarrow S_6$ $\Rightarrow$ $S_5 + \frac{4}{5} S_6 = 0$ $\left\{ \begin{array}{l} S_6 = -20\ kN \\ S_5 = 16\ kN \end{array} \right.$

$S_8 + \frac{3}{5} S_6 = 0$

S_4 is zero-force member , $\Rightarrow$ $S_1 = S_5 = 16\ kN$.

PROBLEM 3 (weight 2,0 - ± 40 min.)   Name: _____

b. (continuation)
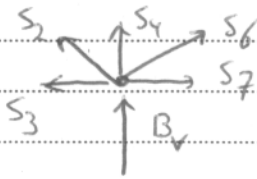
$$\frac{4}{5} S_6 - S_2 - \frac{4}{5} - S_3 + S_7 = 0.$$

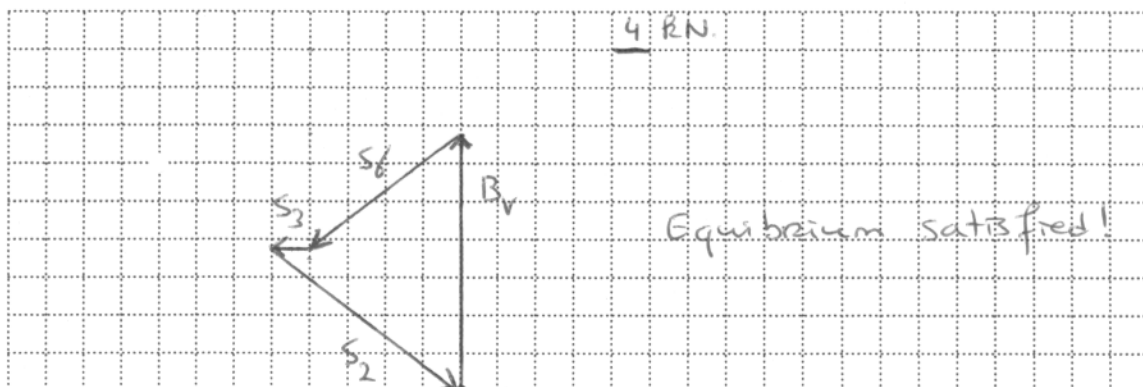$$\frac{3}{5} S_2 + \frac{3}{5} S_6 + S_4 + B_v = 0.$$

$$\Rightarrow \quad S_2 = -25\, kN$$

$$S_3 = 4\, kN.$$

Bar nr.	Force in N
1	16
2	−25
3	4
4	0
5	16
6	−20
7	0
8	12

c. Draw all forces acting on node C. Check whether node C is in equilibrium using a force polygon.
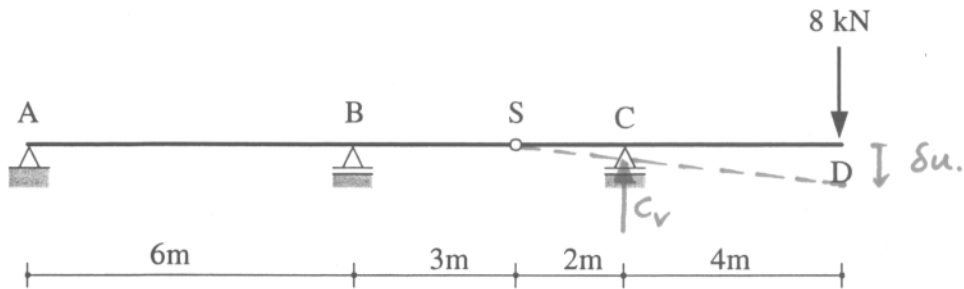
4 kN

Equilibrium satisfied!

PROBLEM 4 (weight 1,5 - ± 30 min.)   Name: _____

You are given the hinged beam in the drawing below.

Question:
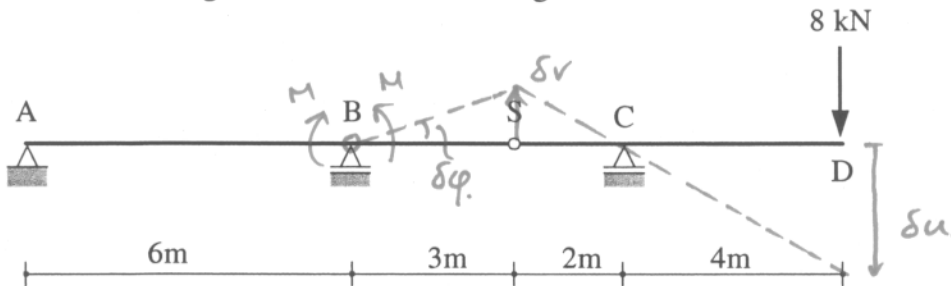a. Calculate, using virtual work, the support reaction in C. Indicate the mechanism.

8 kN

A   B   S   C   D

6m   3m   2m   4m

$$\delta W = 8\,\delta u - C_v \cdot \frac{\delta u}{6} \cdot 2 = 0$$

$$\Rightarrow \quad C_v = 24 \; kN.$$

b. Calculate, using virtual work, the bending moment in B. Indicate the mechanism.

8 kN

A   B   S   C   D

6m   3m   2m   4m

$$\delta W = 8\,\delta u + M\,\delta\varphi = 0$$

$$\frac{\delta v}{2} = \frac{\delta u}{4} \quad ; \quad \delta\varphi = \frac{\delta v}{3} \quad \Rightarrow \quad \delta\varphi = \frac{\delta u}{6}$$

$$\Rightarrow \quad M = -48 \; kNm.$$
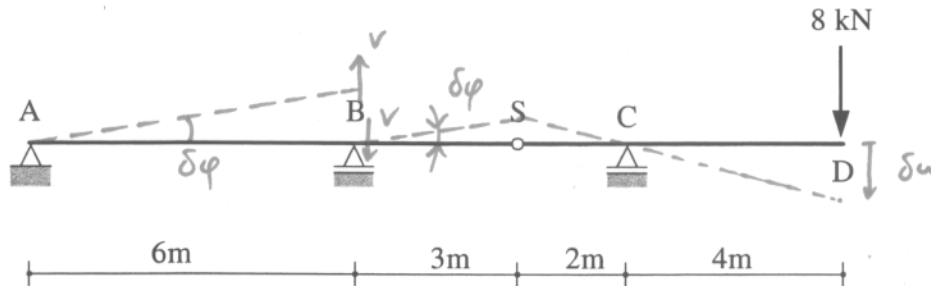
8

PROBLEM 4 (weight 1,5 - ± 30 min.)   Name:

c. Calculate, using virtual work, the shear force directly to the left of B. Indicate the mechanism.

$$\delta W = V \cdot 6 \, \delta\varphi + 8 \, \delta u = 0$$
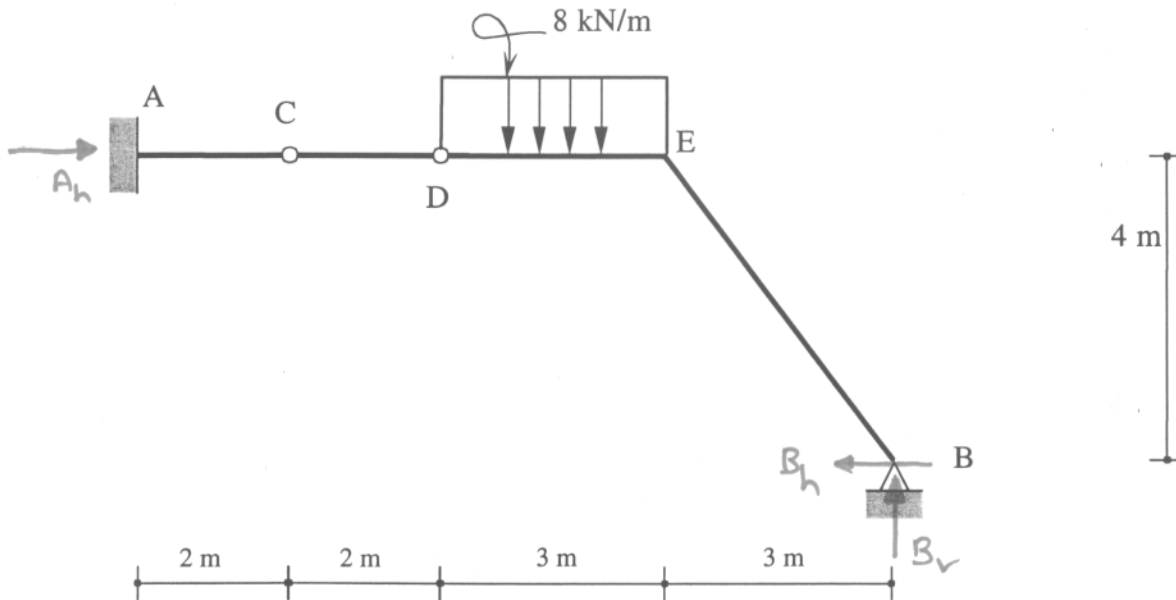
$$\text{where} \quad \delta\varphi = \frac{1}{6} \delta u$$

$$\Rightarrow \quad V = -8 \; kN.$$

PROBLEM 5 (weight 3,0 - ± 50 min.)   Name:

You are given the structure depicted below. A constant distributed vertical load acts on part DE.

Question:
a. Calculate the support reactions and draw them in the figure with the correct sense.

CD is two-force member, therefore only an axial force is present. Thus only $A_h \neq 0$ at the clamped end.

$A_h - B_h = 0$

$\Sigma M_B: \quad 8 \cdot 3 \cdot 4\frac{1}{2} - A_h \cdot 4 = 0 \quad \Rightarrow \quad A_h = B_h = 27 \text{ kN}$

$\Sigma F_v: \quad -8 \cdot 3 + B_v = 0 \quad \Rightarrow \quad B_v = 24 \text{ kN}$

b. Explain how one can immediately see that the moment in A equals zero?
    Substantiate your answer without calculations.

CD is a two-force member. See argument at a).

PROBLEM 5 (weight 3,0 - ± 50 min.)   Name:

c/d/e.   For the entire structure, draw the M- and V-diagrams with the deformation
          signs. Draw the N-diagram with the correct signs for tension and compression.
          Write down the characteristic values. For the M-diagram, also draw the
          tangents in points D and E and clearly indicate where these intersect.

M-diagram

36 kNm

36 kNm

V-diagram.

24 kN

7,2 kN

N-diagram

27 kN

35,4 kN