Space above not to be filled in by the student

Delft Applied Mechanics Course
Statics

AE1-914 part I – 22 January 2009 09.00h - 12.00h

Answer sheets

Last name and initials: Model Answer

Study no.:

Only hand in the answer sheets!
Other sheets will not be accepted

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

Write relevant calculations on the answer sheet
Use the blank sides of the answer sheets if necessary.
Answers without calculations or motivation will not be taken into account.

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

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

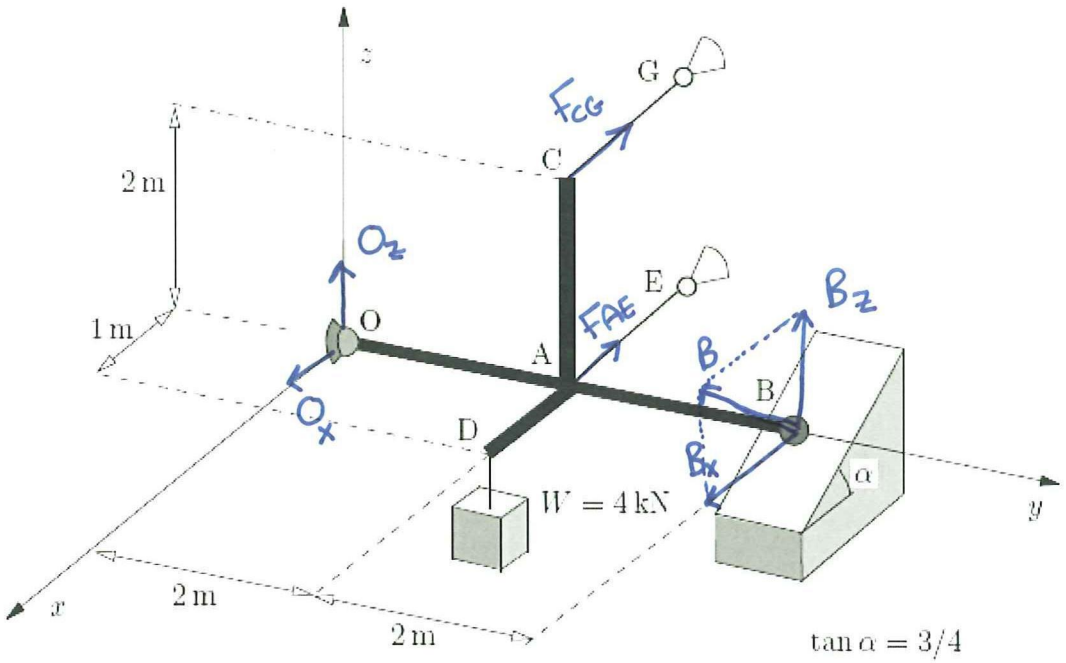
All answers must be given mentioning the correct SI units.

Answer sheets Student no:

Exam Ae1-914 part I Name:

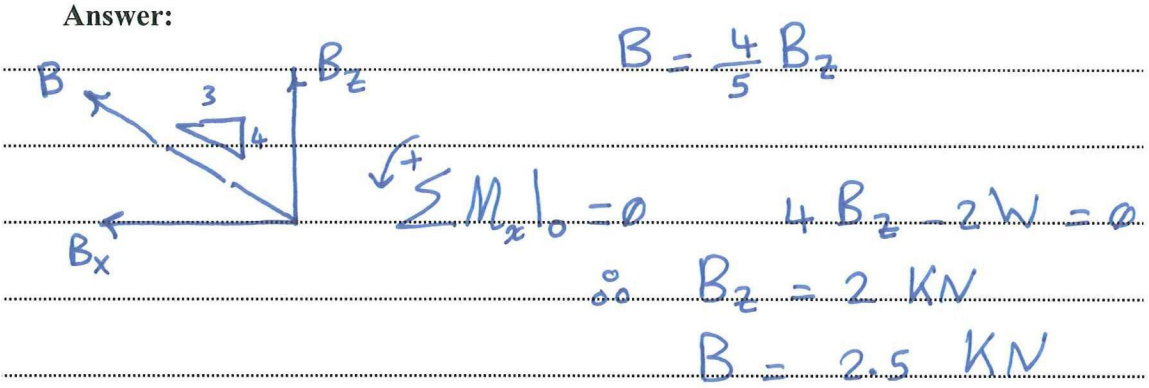
Problem 1 (Weight 2 - approx. 35 minutes)

The structure below consists of beam OAB with arms AC and AD attached perpendicularly. The weight of the structure may be neglected. Point O is a ball and socket joint. The ball that is attached to point B slides over a frictionless slope. The angle α of the slope with respect to the x-axis is equal to tan α = 3=4. The structure is kept in equilibrium by means of the cables AE and CG which are parallel to the x-axis. A mass with a weight of W = 4 kN is attached to point D.



a) Calculate the reaction(s) in B. Draw them in the figure as they act on the structure in reality.

Answer:



Exam Ae1-914 part I Name:

b) Calculate the forces in cables AE and CG.

Answer

$\circlearrowleft + \sum M_y|_D = 0 \quad -2 \cdot F_{CG} + W = 0$

$F_{CG} = 2\ kN$

$\circlearrowleft + \sum M_z|_D = 0 \quad 2F_{CG} + 2F_{AE} - 4B_x = 0$

$F_{AE} = 2B_x - F_{CG} = 1\ kN$

c) Calculate the reaction(s) in the ball- and socket joint O. Draw them in the figure as they act on the structure in reality.

Answer

$\sum F_x = 0 \rightarrow O_x + B_x - F_{CG} - F_{DE} = 0$

$O_x = 1.5\ KN$

$\sum F_y = 0 \rightarrow O_y = 0\ KN$

$\sum F_z = 0 \rightarrow O_z = 2\ KN$

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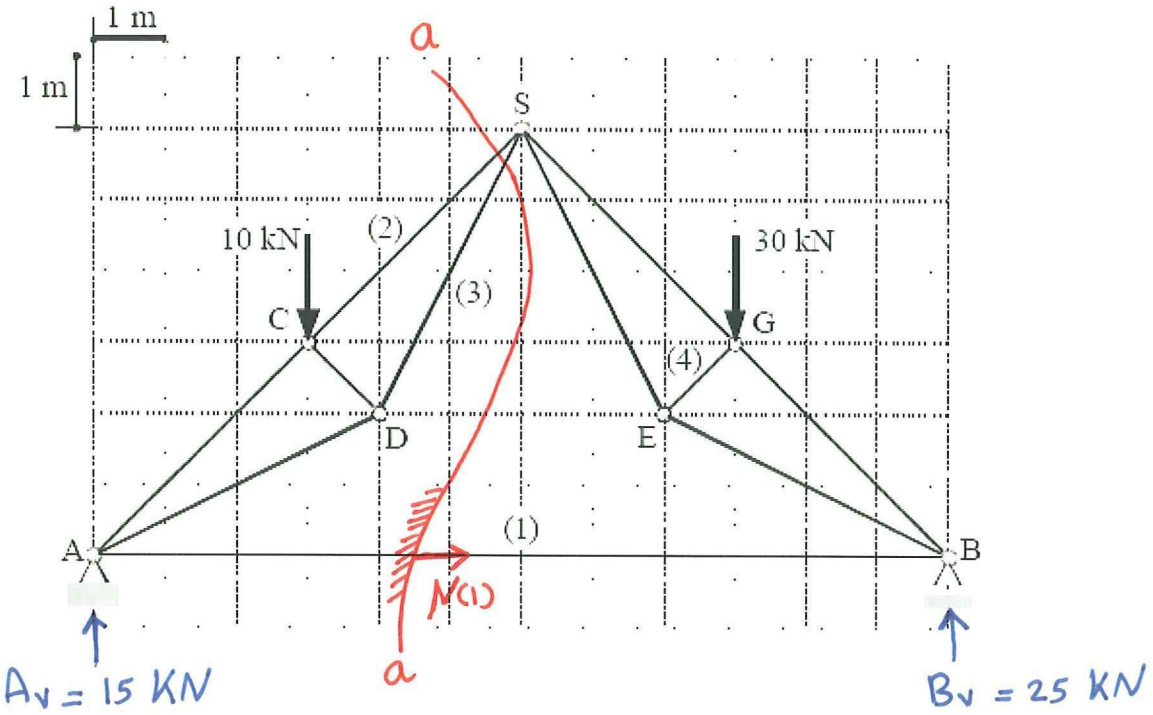
Problem 2 (Weight 2 - approx. 30 minutes)

The truss represented in the figure below has a hinged support in A and a roller support in B. Dimensions can be read from the figure using the grid, the grid distance is 1 m. The loads can be read from the figure as well.



a) Determine the horizontal and vertical component of the reaction forces in A and B. Sketch these forces in the figure in the directions in which they act and give their values.
Answer

$\curvearrowleft +$

$\sum T|_A = 0: B_V(12) - 30(9) - 10(3) = 0$

$\curvearrowright B_V = 25$ KN

$\sum F_{vert} = 0 \curvearrowright A_V = 15$ KN $(\uparrow)$

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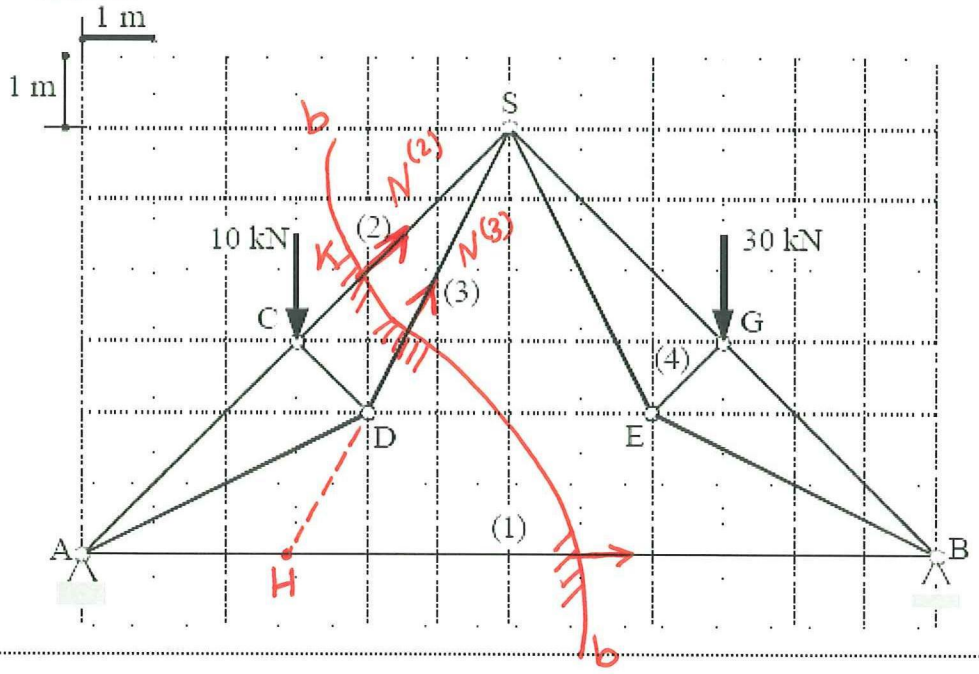
b) Determine by means of the method of sections the force in bar (1). Clearly indicate

Answer



Section a-a

$\curvearrowleft + \sum T|_S^{AS} = N^{(1)} \cdot 6 - 15(6) + 10 \cdot 3 = 0$

$\rightsquigarrow N^{(1)} = 10\ kN$

c) Determine by means of the method of sections the force in bar (2). Clearly indicate the section used.

Answer

Section b-b @ K

Exam Ae1-914 part I Name:

$\curvearrowleft \sum T|_H^{AKH} = \frac{1}{2} N^{(2)} \sqrt{2}(1-4) - 15 \cdot 3 = 0$

$N^{(2)} = -15\sqrt{2}$ kN

d) Determine by means of the method of sections the force in bar (3). Clearly indicate the section used.

Answer

• Section b–b @ H

$\curvearrowleft + \sum T|_A^{AKH} = \frac{2}{5} N^{(3)} \sqrt{5} \cdot 3 - 10 \cdot 3 = 0$

$N^{(3)} = 5\sqrt{5}$ kN

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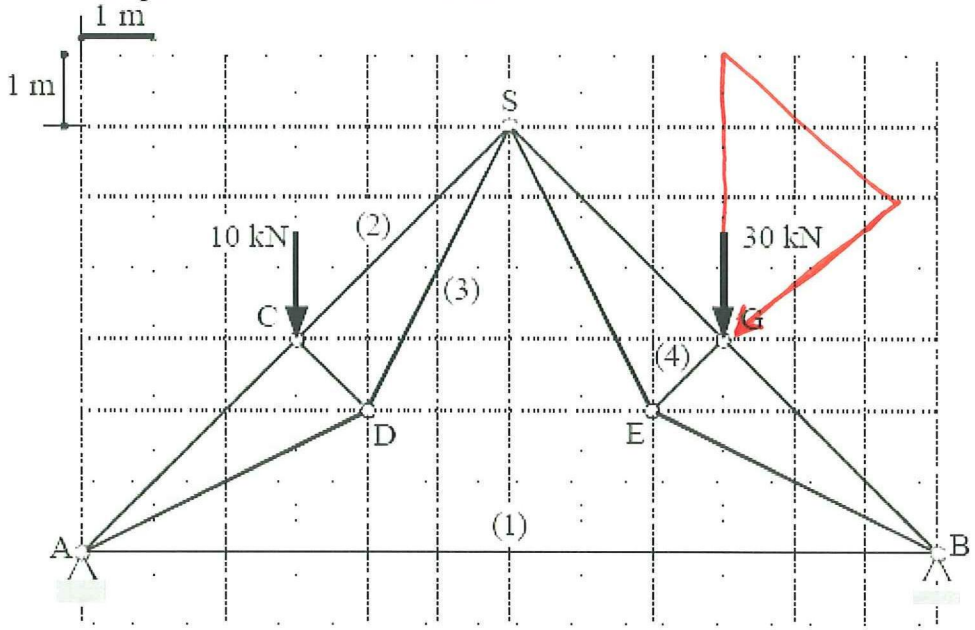
Exam Ae1-914 part I Name:



e) Determine the force in bar (4). The choice of method is free.

Answer

$N^{(4)} = -\frac{1}{2}\sqrt{2} * 30 = -15\sqrt{2}$ kN

f) Assemble the previous results in the table with the correct signs for tension and compression

Answer

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Member	N(KN)
1	$+10$
2	$-15\sqrt{2}$
3	$+5\sqrt{5}$
4	$-15\sqrt{2}$

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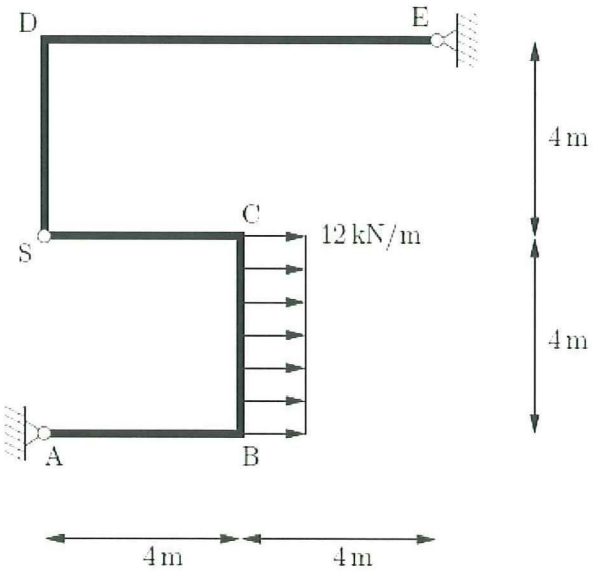
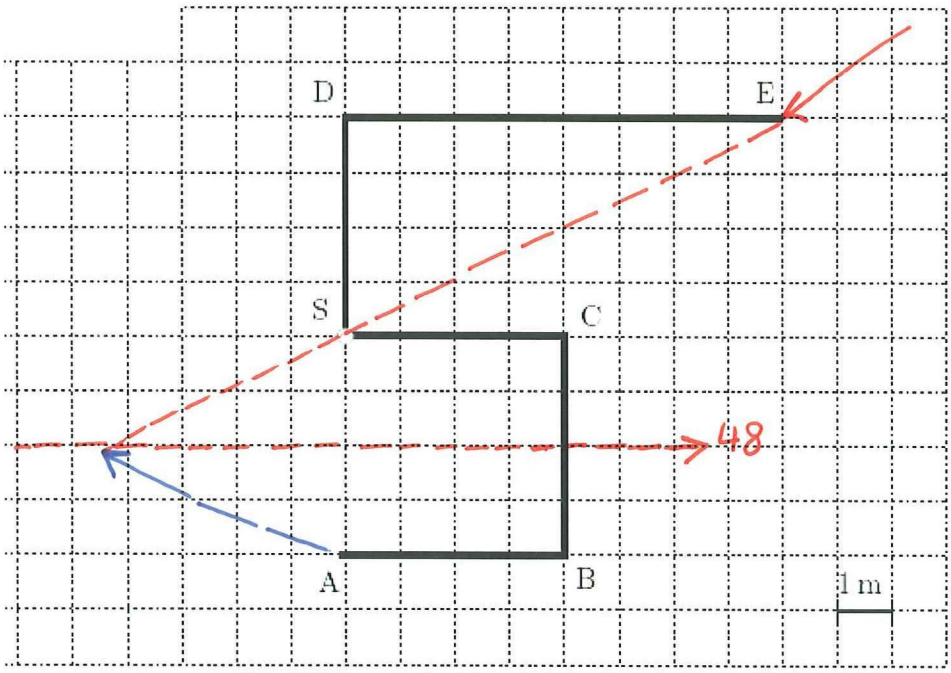
Problem 3 (Weight 2 - approx. 40 minutes)

The structure in the figure consists of two parts (ABCS and SDE) which are hinged together in S.



a) Graphically determine the direction of the reaction force in A.

Answer



Exam Ae1-914 part I Name:

b) Calculate the reactions in A and E. It is permitted to use the solution from the previous question.

Answer

From figure at a) it can be observed

$A_H : A_V$ & $E_H : E_V$

2 : 1 2 : 1

and $A_V = -E_V$ & $A_H = E_H$

$\overset{+}{\rightarrow} \sum F_H = 0 = -A_H - E_H + 12 * 4 = 0$

$\curvearrowright E_H = A_H = 24$ KN

$+\uparrow \sum F_y = 0 \curvearrowright E_V = -12$ KN

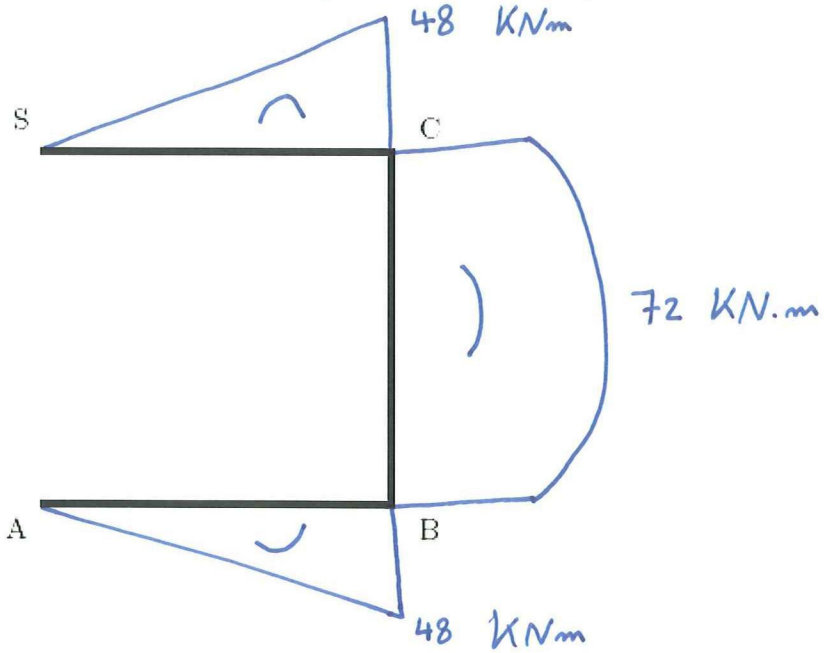
$A_V = 12$ KN

$\therefore E_R = 26,83$ KN

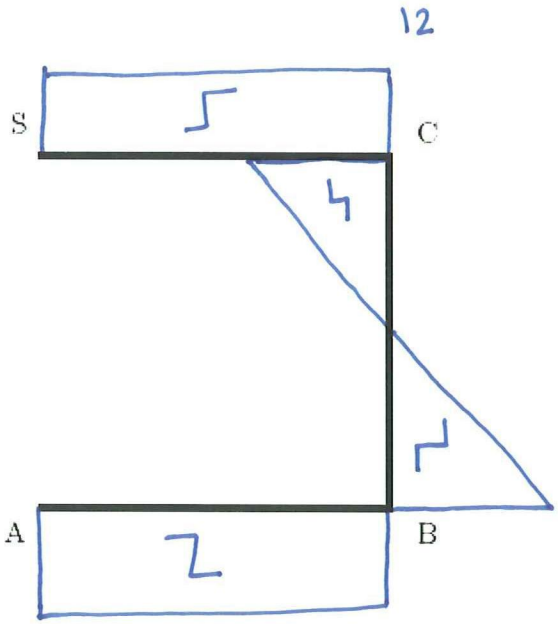
$A_R = 26,83$ KN

c) Draw the moment-diagram (M-diagram) of part ABCS using the correct deformation signs. Mention all relevant values and draw the tangents when necessary.

Answer

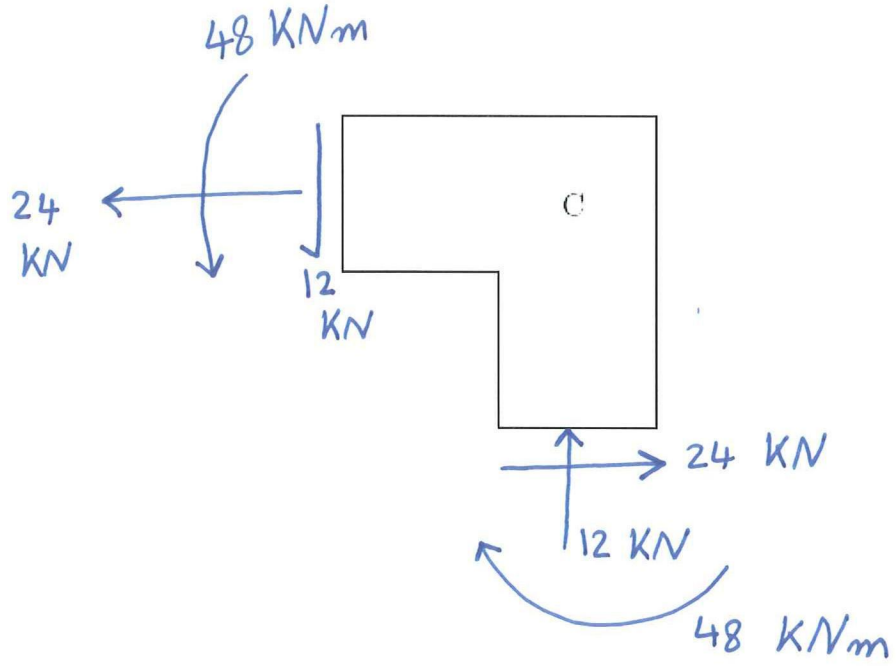


d) Draw the shear force diagram (V -diagram) of part ABCS using the correct deformation signs. Mention all relevant values.



e) Isolate the corner at C and draw all forces and moments as they act on it in reality. State all values of these forces and moments.

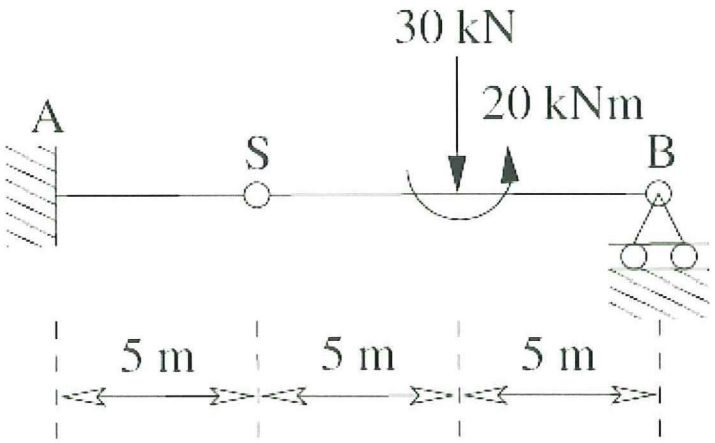
Answer



Exam Ae1-914 part I Name:

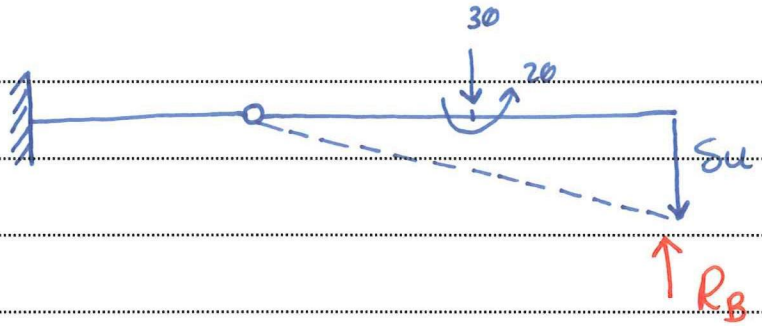
Problem 4 (Weight 2 - approx. 35 minutes)

The structure depicted in the figure consists of a beam AS of length 5 m connected with a pin to a beam BS of length 10 m. The structure is loaded by a force of 30 kN and a couple of 20 kNm halfway along beam BS.



a) Using the principle of virtual work, calculate the reaction force in support B. Clearly indicate the virtual displacement field and the direction of the reaction force.

Answer



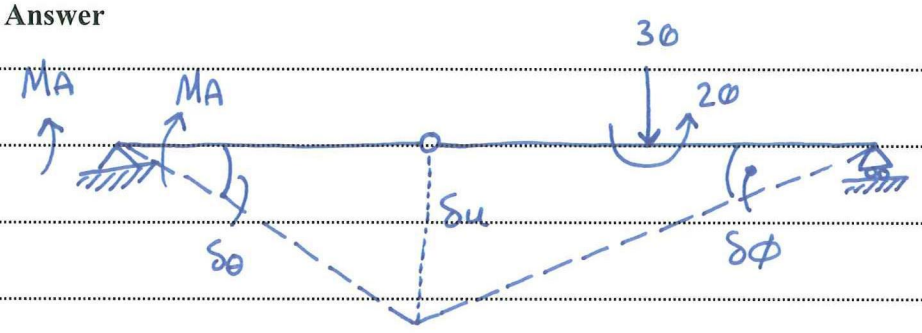
$$\delta W = -R_B \delta u + 30 \cdot \frac{1}{2} \delta u - 20 \cdot \frac{\delta u}{10} = 0$$

$$\curvearrowright \quad R_B = 13 \text{ KN}$$

Exam Ae1-914 part I Name:

b) Using the principle of virtual work, calculate the bending moment in support A. Clearly indicate the virtual displacement _eld and the sign convention used.

Answer



$\delta W = M_A \delta\theta + 30(5)\delta\phi + 20 \cdot \delta\phi = 0$

* Where $\delta\theta(5) = \delta u = \delta\phi(10)$

$\curvearrowright \delta\theta = 2\delta\phi$

$\therefore M_A(2\delta\phi) + 170\delta\phi = 0$

$M_A = -85$ KNm

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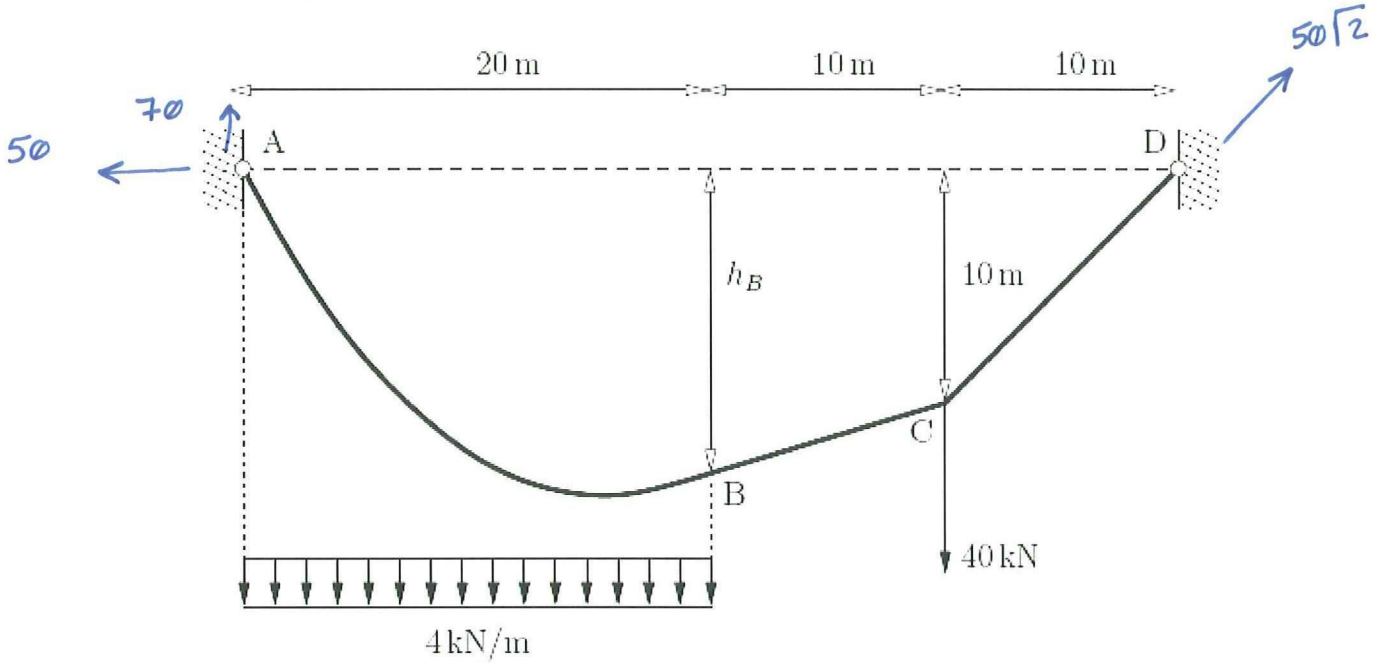
Problem 5 (Weight 2 - approx. 35 minutes)

The cable ABCD in the figure is loaded by a distributed load of 4 kN/m acting on part AB and a single force of 40 kN in C. The sag of point C is 10 meters.



a) Determine the reaction forces in points A and D. Draw them in the figure as they act on the cable in reality.

Answer

Equilibrium of joint D gives $D_H = D_V$

$$\overset{+}{\curvearrowright} \sum T_A = 0 = 4 \times \frac{20^2}{2} - D_V \times 40 + 40 \times 30$$

$$\rightarrow \quad D_V = 50 \text{ KN} \qquad D_H = 20 \text{ KN} \qquad D = 50\sqrt{2} \text{ KN}$$

Exam Ae1-914 part I Name:

$\overrightarrow{+}\ \Sigma F_x = 0 = D_H - A_H \curvearrowright A_H = 50\ KN$

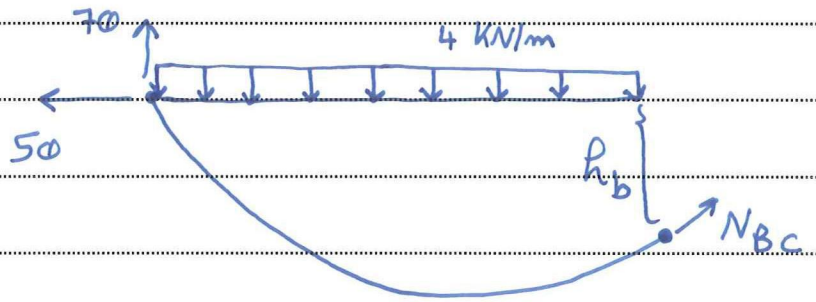
$+\uparrow \Sigma F_y = 0 = A_V + D_V - 4 \times 20 - 40 \curvearrowright A_V = 70\ KN$

$\therefore\ A = 10\sqrt{74}$

b) Determine the sag h_B of point B.

Answer

Consider Equilibrium of AB



$\Sigma T_{B\,(+)} = 0$

$70 \times 20 - q\frac{(20)^2}{2} - 50 h_b = 0$

$\curvearrowright h_b = 12\ m$

Exam Ae1-914 part I Name:

c) Where in the cable does the maximum cable force occur? What is the value of the cable force in that point?

Answer

Cable force has a maximum at max slope

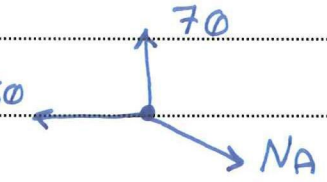
slope at A 70/50 = 1.4 ✓✓

" at BC : 0.2

" at CD : 1

$N_A = \sqrt{50^2 + 70^2} = 10\sqrt{74}$

$\simeq 86$ KN



d) Where in the cable does the sag reach its maximum? What is the maximum sag in this point?

Answer

max. Sag if tangent to cable is horizontal

then also N cable only has horizontal comp.

$+\uparrow \sum F_y = 0 = 70 - q(x)$

max at $x = 17.5$ m from A

Sag:

$\sum T_A +\circlearrowleft = 0 = q\frac{x^2}{2} - 50(y)$

$y = 12.25$ m

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