Delft Applied Mechanics:
Statics

AE1-914-I

October 31, 2005, 14:00–17:00

ANSWER FORM

Studentnumber: | | | | | | | |

Name: Answer model

Please do not write below this line

Grades:

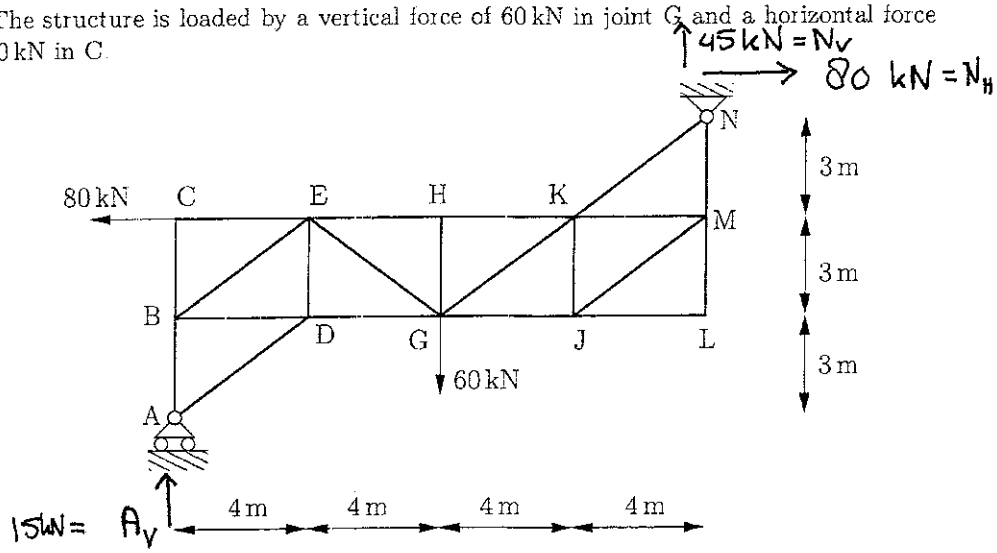
					⟹	

Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Problem 1 (Weight 2 0, approx. 35 min.)

The truss below is supported by a horizontal roller support in A and a pin connection in N. The structure is loaded by a vertical force of 60 kN in joint G and a horizontal force of 80 kN in C.



Question a

Calculate the reactions in A and N. Draw these forces in the figure as they act on the structure in reality.

Answer

$\Sigma M_N \circlearrowleft + : 0 = 3 \cdot 80 - 60 \cdot 8 + A_V \cdot 16$

$16\, A_V = 240$

$A_V = 15\ kN$

$\Sigma F_x \rightarrow + : 0 = N_H - 80 \Rightarrow N_H = 80\ kN$

$\Sigma F_y \uparrow + : 0 = N_V + A_V - 60$

$\rightarrow N_V = 60 - 15 = 45\ kN$

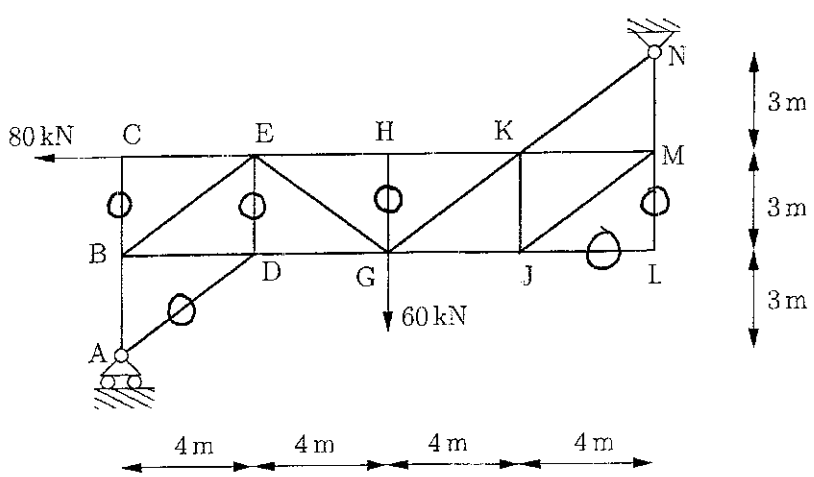
Exam AE1-914-I Studentnumber:

October 31, 2005 Name: answer model

Question b

Which of these members can be immediately identified as zero-force-members? Indicate these members in the figure

Answer

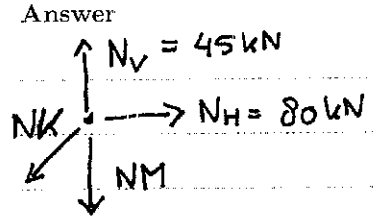


Question c

Calculate the forces in members HK, GK, JK, MK, NK. Use the correct sign for tension and compression.

Answer

node N:



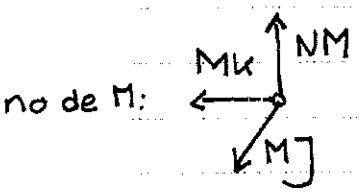
$\Sigma F_x \xrightarrow{+}: 0 = N_H - \frac{4}{5} NK = 0$

$NK = \frac{5}{4} NH = 100$ kN

$\Sigma F_y \uparrow +: 0 = N_V - NM - \frac{3}{5} NK$

$NM = 45 - \frac{3}{5} \cdot 100 = -15$ kN

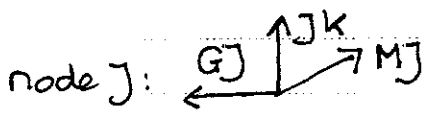
node M:



$\Sigma F_y \uparrow +: 0 = NM - \frac{3}{5} MJ \rightarrow MJ = -\frac{5}{3} \cdot 15 = -25$ kN

$\Sigma F_x \xrightarrow{+}: 0 = -\frac{4}{5} MJ - MK \rightarrow MK = -\frac{4}{5} \cdot 25 = 20$ kN

node J:



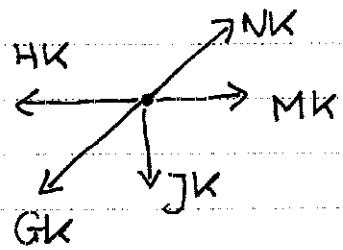
$\Sigma F_y \uparrow +: 0 = JK + \frac{3}{5} MJ$

$JK = -\frac{3}{5} MJ = -\frac{3}{5} \cdot -25 = 15$ kN

Exam AE1-914-I Studentnumber: | | | | | | | |

October 31, 2005 Name: answer model

node K:



$\Sigma F_y \uparrow + : 0 = \frac{3}{5} NK - JK - \frac{3}{5} GK$

$GK = NK - \frac{5}{3} JK$

$GK = 100 - 5/3 \cdot 15 = 75\ kN$

$\Sigma F_x \rightarrow + : 0 = \frac{4}{5} NK + MK - HK - \frac{4}{5} GK$

$HK = \frac{4}{5} NK + MK - \frac{4}{5} GK$

$HK = \frac{4}{5} 100 + 20 - \frac{4}{5} 75$

$HK = 40\ kN$

Collect all results in the table below

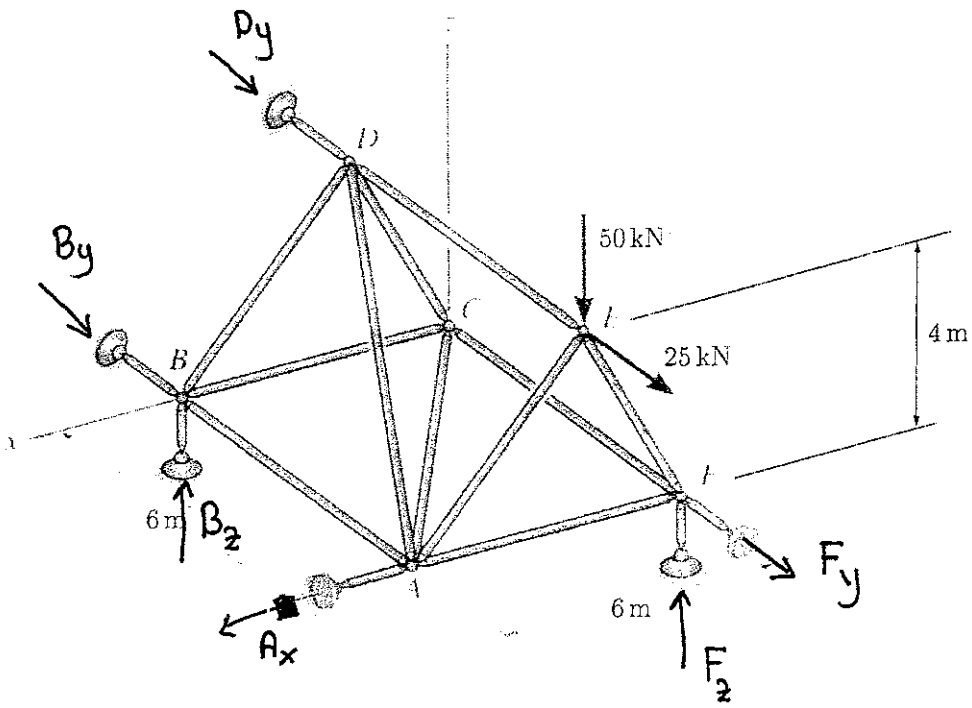
F_{HK}	F_{GK}	F_{JK}	F_{MK}	F_{NK}
40 kN	75 kN	15kN	20 kN	100 kN

Exam AE1-914-I Studentnumber:

October 31, 2005 Name: answer model

Problem 2 (Weight 2.0, approx. 35 min)

The 3-dimensional truss in the figure below is loaded in joint E by a force of 25 kN in the positive y-direction and a force of 50 kN in the negative z-direction.



Question a

Calculate all reactions.

Answer

$\Sigma F_x \overset{+}{\rightarrow}_x : 0 = A_x \rightarrow \underline{A_x = 0\ kN}$

$\Sigma M_y \overset{+}{\uparrow}_y : 0 = 50 \cdot 3 - B_z\, 6 \rightarrow \underline{B_z = 25\ kN}$

$\Sigma F_z \uparrow + : 0 = F_z + B_z - 50 \rightarrow \underline{F_z = 25\ kN}$

$\Sigma M_x \curvearrowleft + = 0 = -50 \cdot 6 - 25 \cdot 4 + F_z \cdot 6 - D_y \cdot 4$

$$D_y = \frac{F_z \cdot 6 - 100 - 300}{4} = -62\tfrac{1}{2}\ kN$$

$$\underline{D_y = -62\tfrac{1}{2}\ kN}$$

$\Sigma M_z \curvearrowleft + = 0 = B_y \cdot 6 + D_y \cdot 3 + 25 \cdot 3$

$$B_y = \frac{-3 \cdot D_y - 75}{6}$$

$$= \frac{-3 \cdot -62\tfrac{1}{2} - 75}{6}$$

$$\Rightarrow \quad \underline{B_y = 18.75\ kN}$$

$\Sigma F_y \uparrow + = 0 = F_y + B_y + D_y + 25$

$$F_y = -25 - B_y - D_y$$

$$= -25 - 18.75 + 62\tfrac{1}{2}$$

$$\Rightarrow \quad \underline{F_y = 18.75\ kN}$$

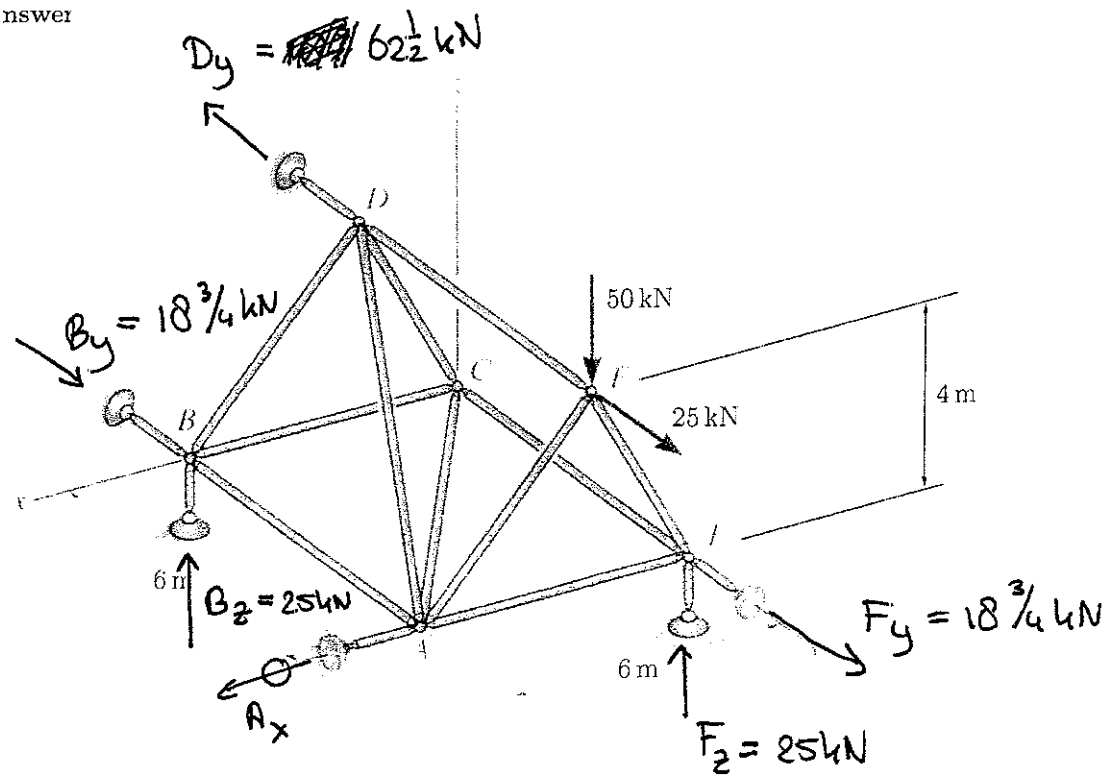
Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Question b

Draw all support reactions in the figure as they act on the structure in reality

Answer

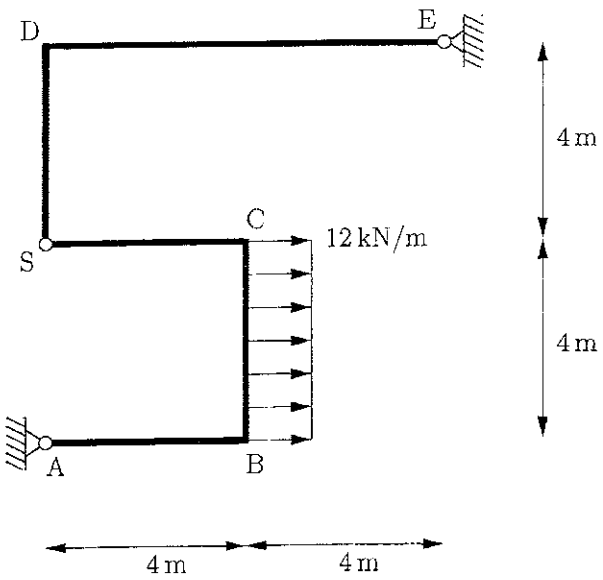


Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Problem 3 (Weight 2 0, approx. 35 min.)

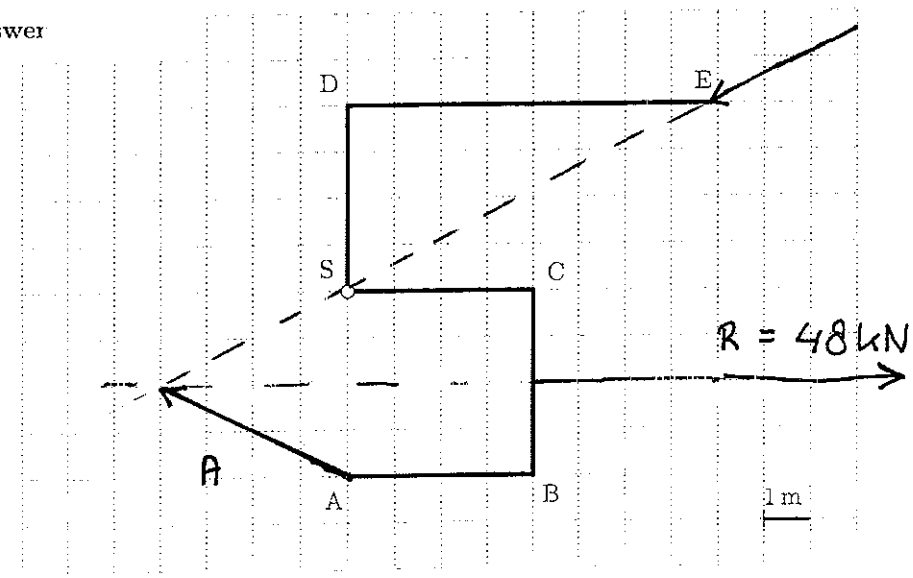
The structure in the figure consists of two parts (ABCS and SDE) which are hinged together in S.



Question a

Graphically determine the direction of the reaction force in A.

Answer



Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Question b

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

Answer

From the figure at a) it can be observed that:

$A_H : A_V$ & $E_H : E_V$

2 : 1 2 : 1

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

$\Sigma F_H \overset{+}{\rightarrow} : 0 \quad -A_H - E_H + 12 \cdot 4 = 0$

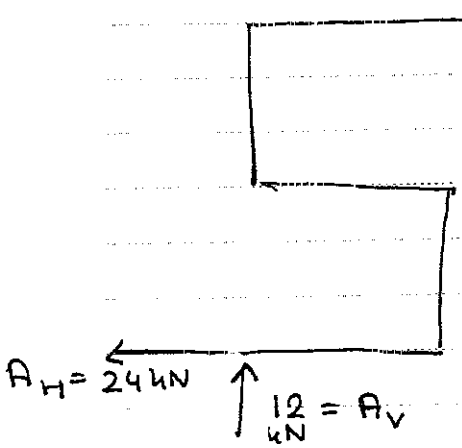
$\rightarrow \quad E_H = A_H = \underline{24\ kN}$

$\Sigma F_y \uparrow + \rightarrow \quad E_V = -12\ kN$

$\not{E} A_V = \overline{+12\ kN}$

$\downarrow E_V = 12\ kN$

$E_H = 24kN$



$E_R = \sqrt{E_H^2 + E_V^2}$

$= 26,83\ kN$

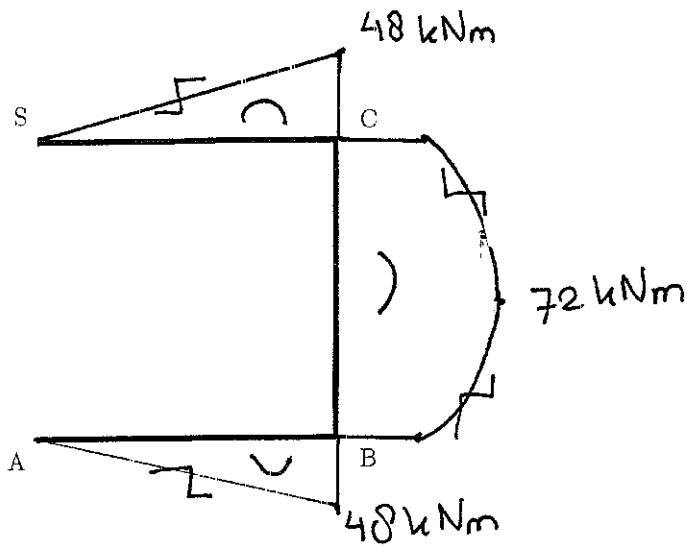
$A_R = \sqrt{A_H^2 + A_V^2}$

$= 26.83kN$

Question 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.

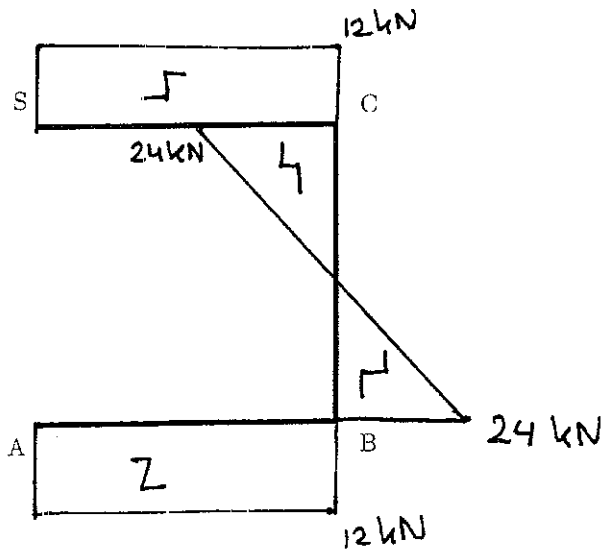
Answer



Question d

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

Answer



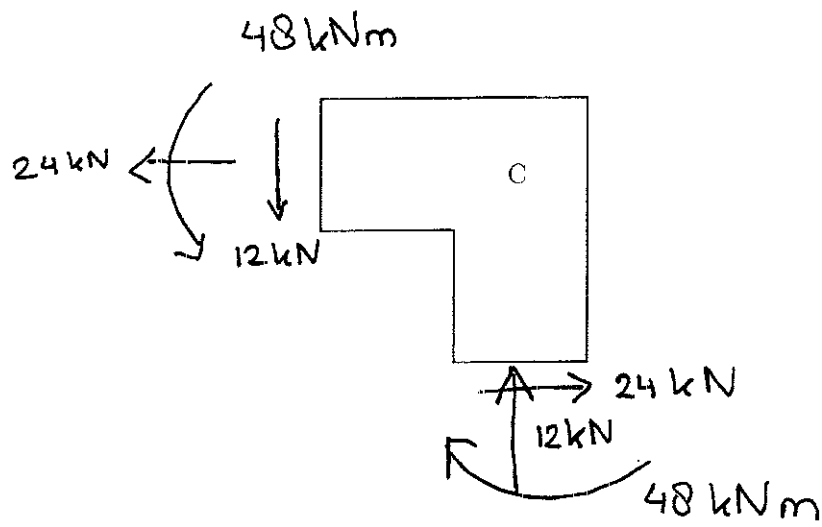
Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Question 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

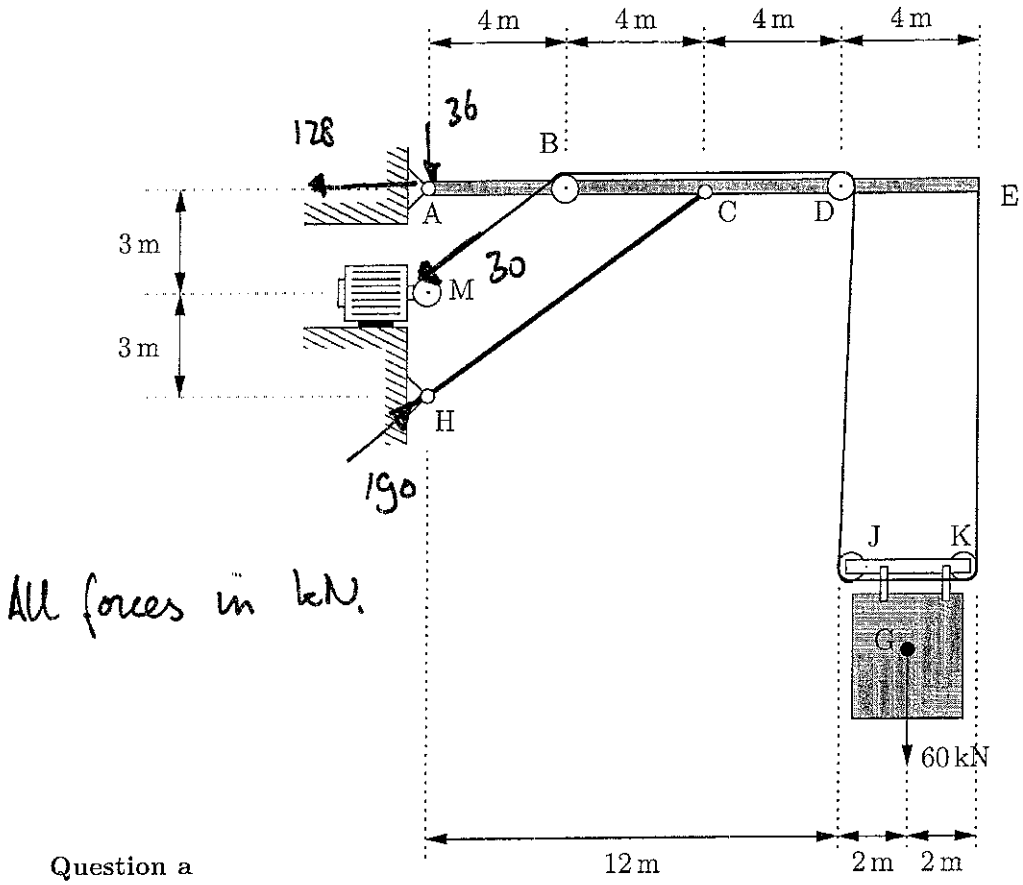


Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Problem 4 (Weight 2.5, approx. 45 min)

The crane in the figure is used to load sea containers onto trucks. The beam ABCDE is supported by a hinge in A and the two-force member CH. The container is suspended from a cable which in turn is connected to point E and leads to the engine at M via the frictionless pulleys K, J, D and B. All pulleys have the same radius and the dimensions of the pulleys are negligible in comparison to the other dimensions of the crane. The weight of the container is 60 kN and its line of action goes through the centre of mass G of the container. The mass of the crane itself may be neglected.



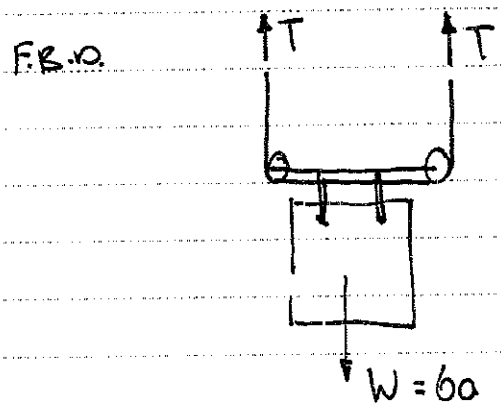
All forces in kN.

Question a

Calculate the force in the cable.

Answer

PLEASE TURN OVER



ΣF_y: $2T - W = 0$

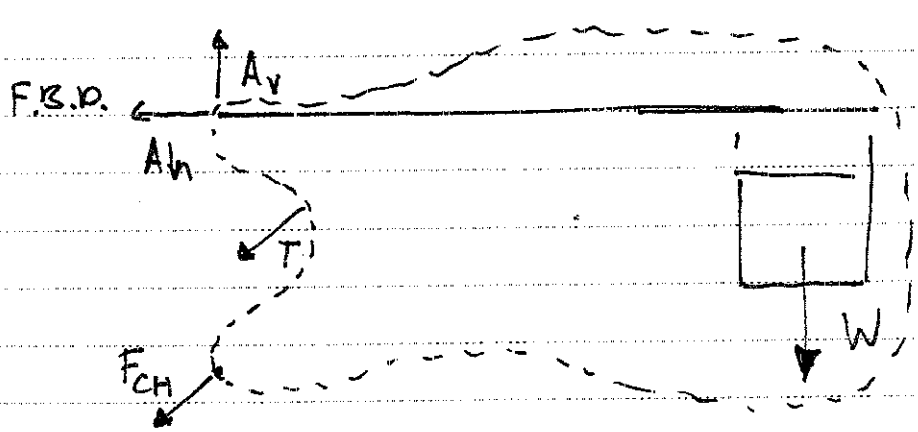
$2T = W = 60$ kN.

$T = 30$ kN.

Question b

Calculate the reactions in A and H and draw them in the figure on the previous page as they act on the structure in reality. (*Hint: When drawing the free-body diagram, do not forget the force in the cable!*)

Answer



$\Sigma M_A^{\circlearrowleft}$: $-3 \cdot \frac{4}{5} T - 14 W - 6 \cdot \frac{4}{5} F_{CH} = 0$

$F_{CH} = -190$ kN

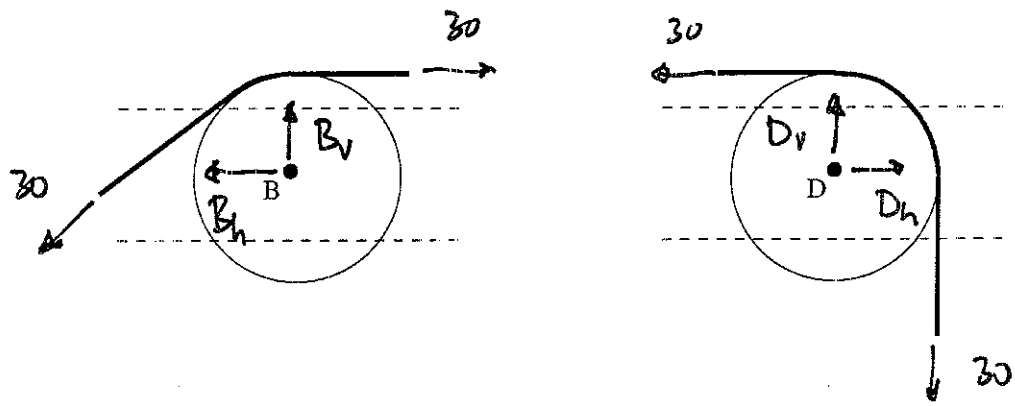
$\Sigma F_x^{\rightarrow}$: $-A_h - \frac{4}{5} F_{CH} - \frac{4}{5} T = 0$ $\quad A_h = 128$ kN

$\Sigma F_y \uparrow$: $A_V - \frac{3}{5}T - \frac{3}{5}F_{CH} - W = 0$

$A_V = -36$ kN.

Question c

Draw the free-body diagram of pulleys B and D and calculate the reactions



Answer

Pulley B: $\Sigma F_x \rightarrow$: $-B_h - \frac{4}{5}T + T = 0 \Rightarrow B_h = 6$ kN

$\Sigma F_y \uparrow$: $B_V - \frac{3}{5}T = 0$ $B_V = 18$ kN

Pulley D: $\Sigma F_x \rightarrow$: $-T + D_h = 0$ $D_h = 30$ kN

$\Sigma F_y \uparrow$: $D_V - T = 0$ $D_V = 30$ kN

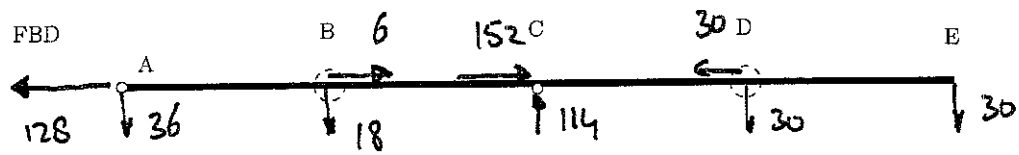
Exam AE1-914-I Studentnumber:

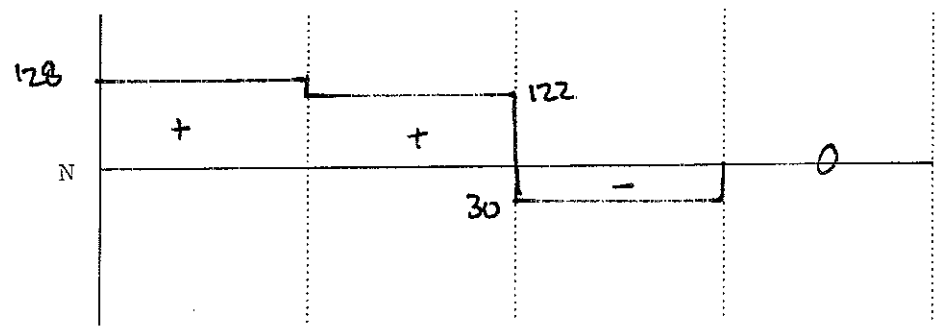
October 31, 2005 Name:

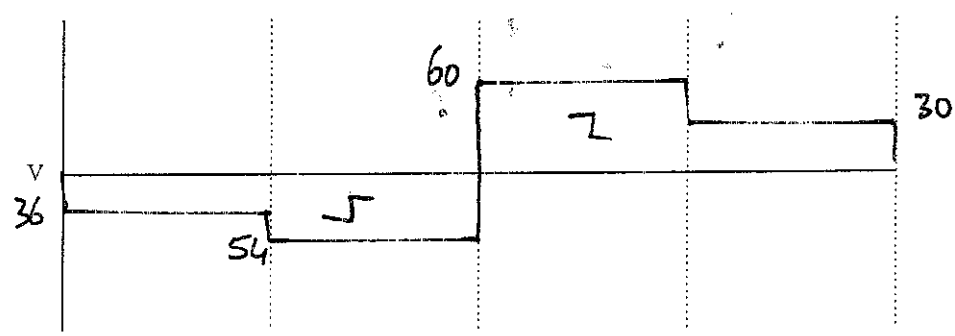
Question d

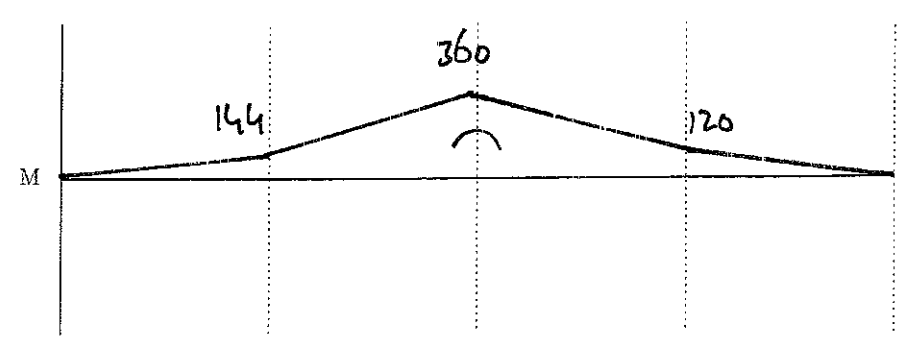
Isolate beam ABCDE and draw all forces which act on it. Also draw the N-, V-, and M-diagrams.

Answer







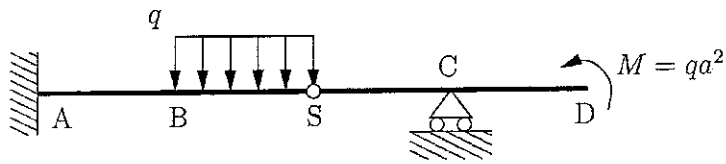


Exam AE1-914-I Studentnumber:

October 31, 2005 Name:

Problem 5 (Weight 1.5, approx. 30 min)

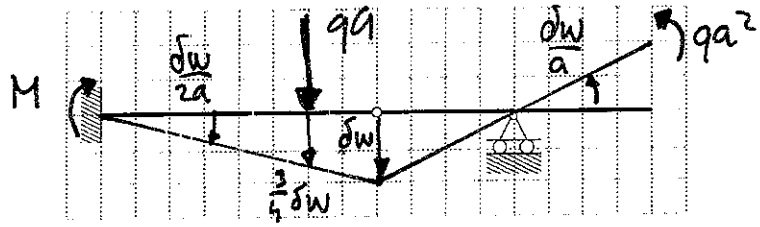
Beam ABSCD in the figure has a fixed support in A and a roller support in C The beam is loaded by a uniform distributed load q kN/m in section BS and a moment M with magnitude qa^2 kNm in D S is a hinge.



Question a

Use the principle of virtual work to calculate the moment reaction in A. Clearly indicate which virtual field of displacement and which sign conventions have been used

Answer



$$\delta \bar{U} = M\frac{\delta w}{2a} + qa \cdot \frac{3}{4}\delta w + qa^2\frac{\delta w}{a} = 0$$

$$\delta w\left[\frac{M}{2a} + \frac{3}{4}qa + qa\right] = 0$$

$$M = -\frac{7}{2}qa^2 \quad [\text{kNm}]$$

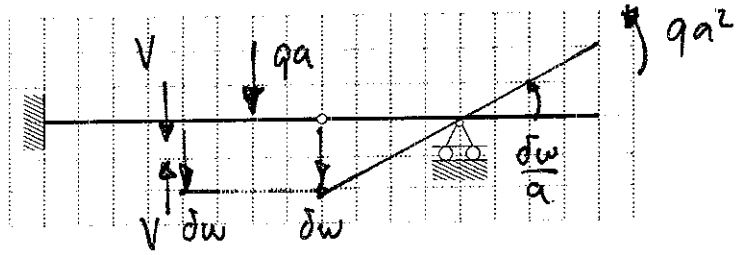
Exam AE1-914-I Studentnumber: | | | | | | | |

October 31, 2005 Name:

Question b

Use the principle of virtual work to calculate the shear force in B Clearly indicate which virtual field of displacement and which sign conventions have been used

Answer



$$\delta\bar{U} = -\delta w \cdot V + qa\,\delta w + qa^2 \frac{\delta w}{a} = 0$$

$$\delta w \left[-V + 2qa \right] = 0$$

$$V = 2qa \quad [kN]$$