Space above not to be filled in by the student

AE1103 Statics

5 November 2010 09.00h - 12.00h

Answer sheets

Last name and initials: Answer model

Student 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.**

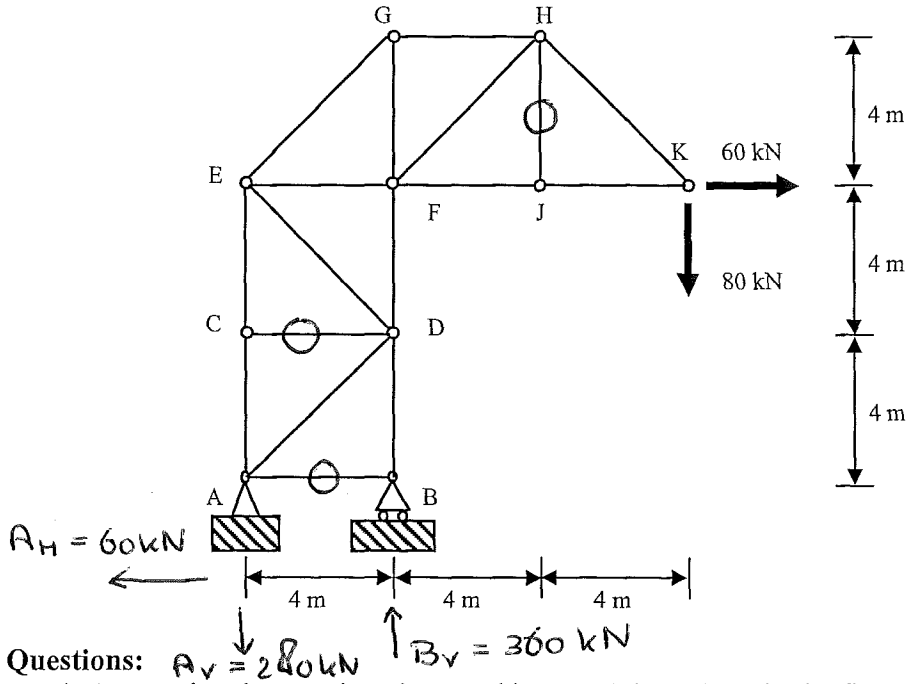
The **neatness of the presentation** of the answers will be considered in the marking.

All answers must be given mentioning the correct SI units.

Answer sheets Student no:

5 November 2010
Exam AE103 Statics Name: Answermodel

Problem 1 (Weight 2.0 - approx. 35 minutes)
The truss structure in the figure below is loaded in K with loads as indicated. All relevant values can be found in the figure.
Het onderstaande vakwerk wordt in K belast met de aangegeven krachten. Alle relevante gegevens kunnen in de figuur worden gevonden.



Questions:

a) Determine the reactions in A and in B and draw these in the figure in the direction in which they act on the structure in reality.
Bepaal de oplegreacties in A en in B en teken deze in de figuur zoals ze in werkelijkheid op de constructie werken.

$\Sigma F_x \rightarrow : 0 = 60 - A_H \rightarrow A_H = 60\ kN$

$\Sigma M_A \circlearrowleft : 0 = B_V \cdot 4 - 80 \cdot 12 - 60 \cdot 8 \rightarrow B_V = 360kN$

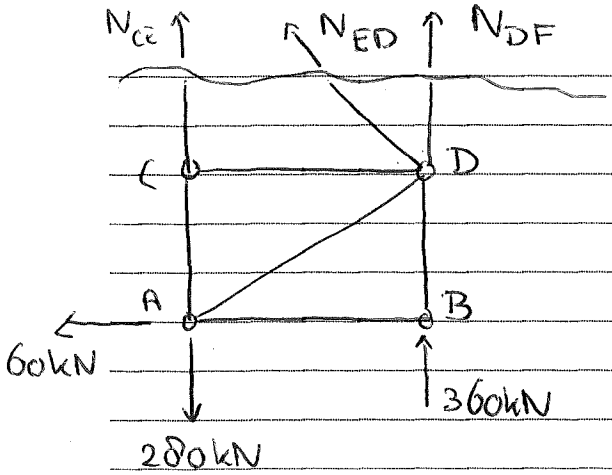
$\Sigma F_y \uparrow : 0 = B_V - A_V - 80 \rightarrow A_V = 280kN$

(problem 1 continued)

b) Identify the zero-force members in the structure.
Identificeer de nulstaven in deze constructie.

JH, CD, AB

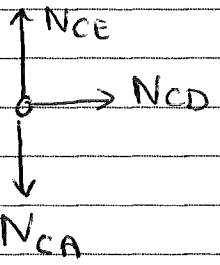
c) Calculate the normal forces in members ED, CD FH, EG, FD and HK using a method of your choice with the correct sign for tension (+) or compression (-) and include these in the table on the next page. All results must be supported by calculations.
Bereken met een methode naar keuze de normaalkrachten in de staven ED, CD, FH, EG, FD *en* HK *met het juiste teken voor trek (+) en druk (-) en vermeld ze in de tabel op de volgende pagina. Alle resultaten moeten met berekeningen worden onderbouwd.*



$\Sigma F_x \rightarrow : 0 = -60 - \frac{1}{2}\sqrt{2}\, N_{ED}$

$N_{ED} = -60\sqrt{2}\ kN$

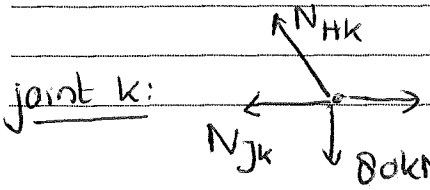
joint C:



$\Sigma F_x \rightarrow : 0 = N_{CD}$

$\rightarrow N_{CD} = 0\ kN$

joint K:



$\Sigma F_y \uparrow : 0 = \frac{1}{2}\sqrt{2}\, N_{HK} - 80$

$N_{HK} = 80\sqrt{2}\ kN$

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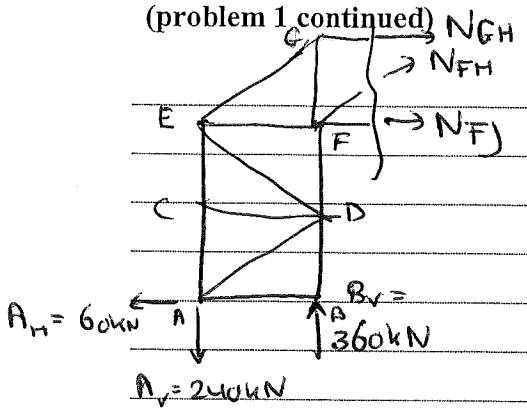
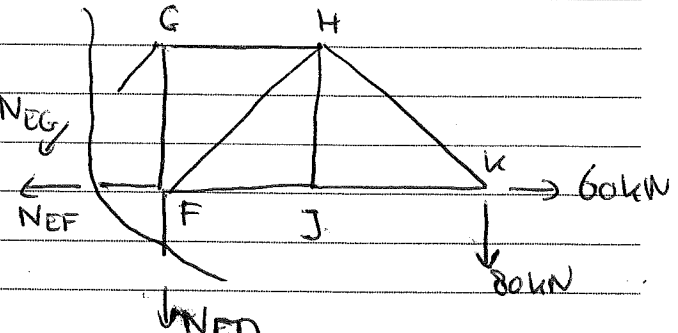
(problem 1 continued)



$\Sigma F_y \uparrow + : 0 = \frac{1}{2}\sqrt{2} N_{FH} + B_V - A_V$

$N_{FH} = -80\sqrt{2}$ kN



$\Sigma M_F^{+}) = -80 \cdot 8 + \frac{1}{2}\sqrt{2} N_{EG} \cdot 4 \rightarrow N_{EG} = 160\sqrt{2}$ kN

$\Sigma F_y \uparrow + : 0 = -\frac{1}{2}\sqrt{2} N_{EG} - N_{FD} - 80$

$N_{FD} = -240$ kN

N_{ED}	N_{CD}	N_{FH}	N_{EG}	N_{FD}	N_{HK}
$-60\sqrt{2}$ kN	0 kN	$-80\sqrt{2}$ kN	$160\sqrt{2}$ kN	-240 kN	$80\sqrt{2}$ kN

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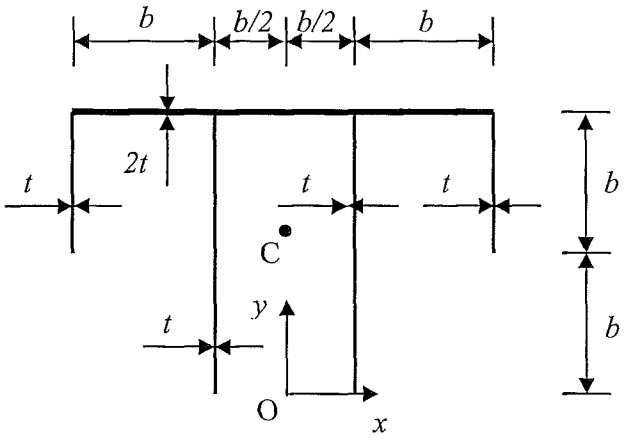
Problem 2 (Weight 1.5 - approx. 35 minutes)
A *thin-walled* cross-section of a beam is given in the figure below. All relevant dimensions are given. Use of the assumptions of *thin-walled* structures is mandatory.
In de onderstaande figuur is een dunwandige doorsnede van een balk weergegeven. Alle relevante afmetingen staan in de figuur. Het is verplicht om gebruik te maken van de aannames voor dunwandige constructies.



Questions

a) Calculate the coordinates of the centroid $(\bar{x},\bar{y})$ with respect to the coordinate system given.
Bereken de coördinaten van het zwaartepunt $(\bar{x},\bar{y})$ in het gegeven coördinatenstelsel.

$\bar{x} = 0$ due to symmetry

$$\bar{y} = \frac{\Sigma y_i A_i}{\Sigma A_i} = \frac{3b \cdot 2t \cdot 2b + 2bt \cdot \frac{3}{2}b + 2 \cdot 2bt \cdot b}{3b \cdot 2t + 2bt + 2 \cdot 2bt}$$

$$\bar{y} = \frac{19}{12} b$$

(Problem 2 continued)

b) Calculate the principal moment of inertia about the y-axis through the centroid in C.
Bereken het centrale hoofdtraagheidsmoment om de y-as door het zwaartepunt in C.

$$I_{yy} = 2bt\left(\tfrac{3}{2}b\right)^2 + 2\cdot 2bt\left(\tfrac{b}{2}\right)^2 + \tfrac{1}{12}2t(3b)^3$$

$$I_{yy} = 10b^3t$$

c) Calculate the principal moment of inertia about the x-axis through the centroid in C.
Bereken het centrale hoofdtraagheidsmoment om de x-as door het zwaartepunt in C.

$$I_{xx} = 2\left\{\tfrac{1}{12}(2b)^3t + (\bar{y}-b)^2\cdot 2bt\right\} + 2\left\{\tfrac{1}{12}b^3t + (\bar{y}-\tfrac{3}{2}b)^2bt\right\} + 3b\cdot 2t\,(2b-\bar{y})^2$$

$$I_{xx} = \frac{47}{12}b^3t$$

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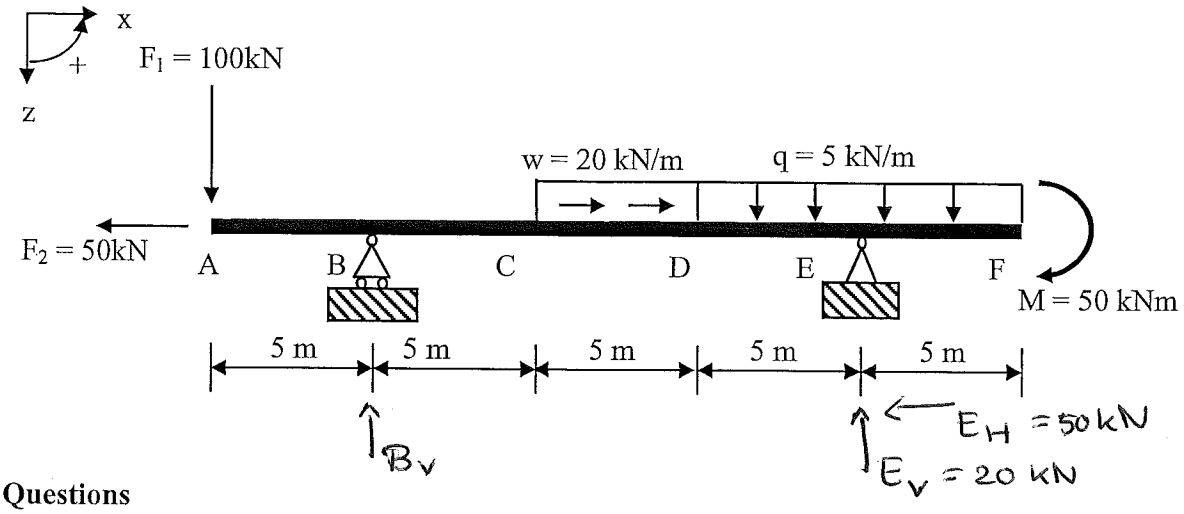
Problem 3 (Weight 2.5 - approx. 40 minutes)

Given beam ABCDEF loaded as shown in the figure below. All relevant values are given in the figure.
Gegeven balk ABCDEF die belast is zoals aangegeven in de figuur. Alle relevante gegevens staan in de figuur.



Questions

a) Calculate the reactions in B and E and draw these in the figure in the direction in which they act on the structure in reality.
Bepaal de oplegreacties in B en in E en teken deze in de figuur zoals ze in werkelijkheid op de constructie werken.

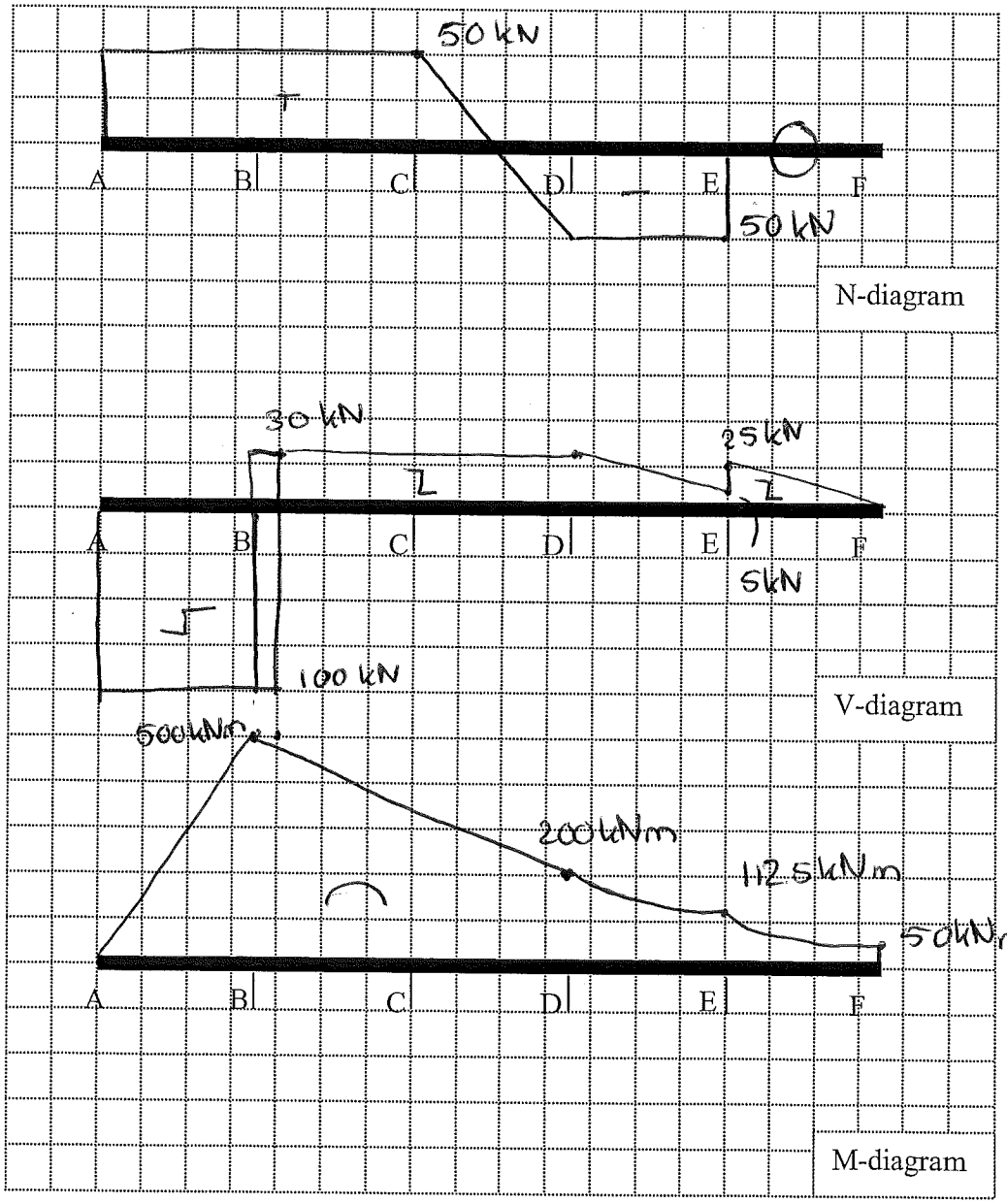
$\Sigma F_x \overset{+}{\rightarrow} : 0 = -50 + 20 \cdot 5 - E_H \rightarrow E_H = 50\,kN$

$\Sigma M_{B\,(+)} : 0 = 100 \cdot 5 - 5 \cdot 10 \cdot 15 + E_V \cdot 15 - 50 \rightarrow E_V = 20\,kN$

$\Sigma F_z \downarrow + : 0 = -B_V - E_V + q \cdot 10 + 100 \rightarrow B_V = 130\,kN$

(Problem 3 continued)

b) Draw the normal force, shear force and moment diagrams (N-, V- and M-diagram) of the beam and use the correct deformation signs. Mention all relevant values including all (local) extremes.
Teken de normaalkrachten-, dwarskrachten- en momentenlijnen (N-, V- en M-lijnen) voor de ligger en vermeld daarbij de juiste vervormingstekens. Vermeld alle relevante waardes inclusief alle (locale) extreme waardes.



(Problem 3 continued)
Room for relevant calculations.
Ruimte voor relevante berekeningen.

$M_E = \frac{5 \cdot 5 \cdot 5}{2} + 50 = 112.5 \text{ kNm}$

$M_B = 100 \cdot 5 = 500 \text{ kNm}$

$M_C = 100 \cdot (5+5) - 130 \cdot 5 = 200 \text{ kNm}$

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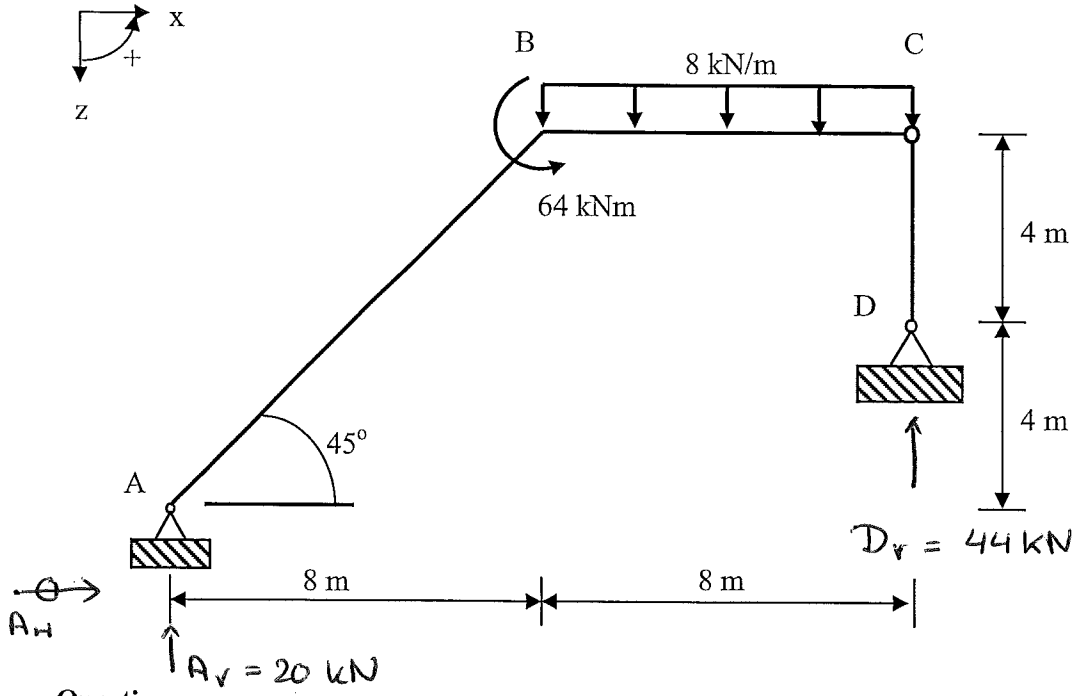
Problem 4 (Weight 2.5 - approx. 40 minutes)

The structure in the figure below is loaded as shown. Link CD is a two-force member, ABC is a beam. All relevant values are given in the figure below.
De onderstaande constructie wordt belast zoals in de figuur aangegeven. Staaf CD is een pendelstaaf. Alle relevante waardes staan in de figuur.



Questions

a) What is the definition of a two-force member?
Wat is de definitie van een pendelstaaf?

A two-force member is a member that has only 2 forces acting on it whose lines of action coincide with the centerline of the member and hence only a normal force is present in that member.

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(Problem 4 continued)

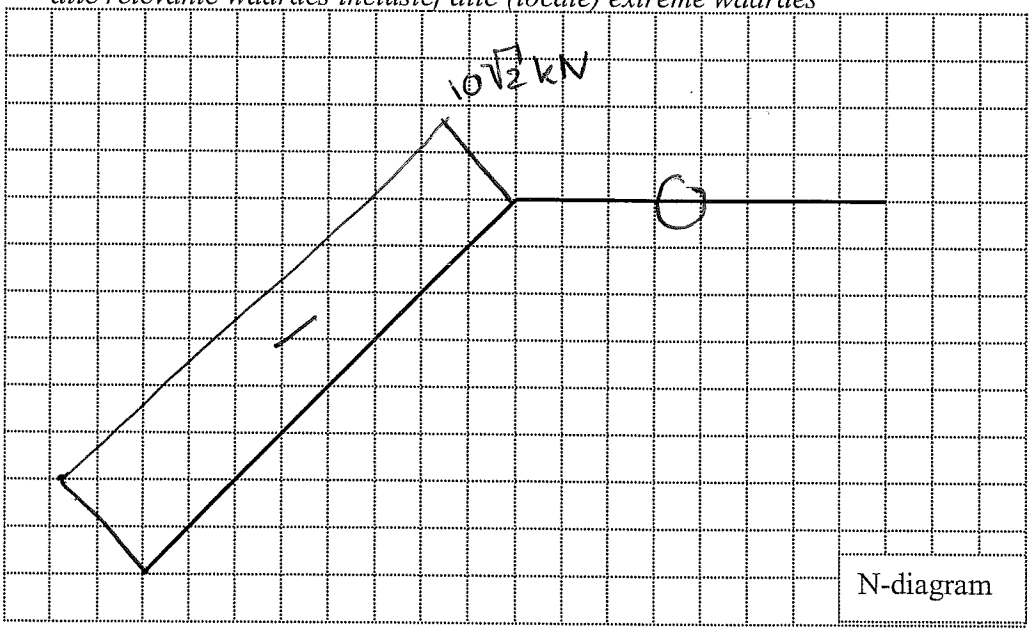
b) Calculate the reactions in A and D and draw these in the figure in the direction in which they act on the structure in reality.
Bepaal de oplegreacties in A en in D en teken deze in de figuur zoals ze in werkelijkheid op de constructie werken.

$\Sigma F_x \rightarrow : 0 = A_H \rightarrow A_H = 0\ kN$

$\Sigma M_A \circlearrowleft : 0 = D_V \cdot 16 + 64 - 8 \cdot 8 \cdot 12 \rightarrow D_V = 44 kN$

$\Sigma F_z \downarrow + : 0 = -D_V - A_V + 8 \cdot 8 \rightarrow A_V = 20\ kN$

c) Draw the normal force, shear force and moment diagrams (N-, V- and M-diagram) of the frame and use the correct deformation signs. Mention all relevant values including all (local) extremes.
Teken de normaalkrachten-, dwarskrachten- en momentenlijenn (N-, V- en M-lijnen) voor de ligger en vermeld daarbij de juiste vervormingstekens. Vermeld alle relevante waardes inclusief alle (locale) extreme waardes



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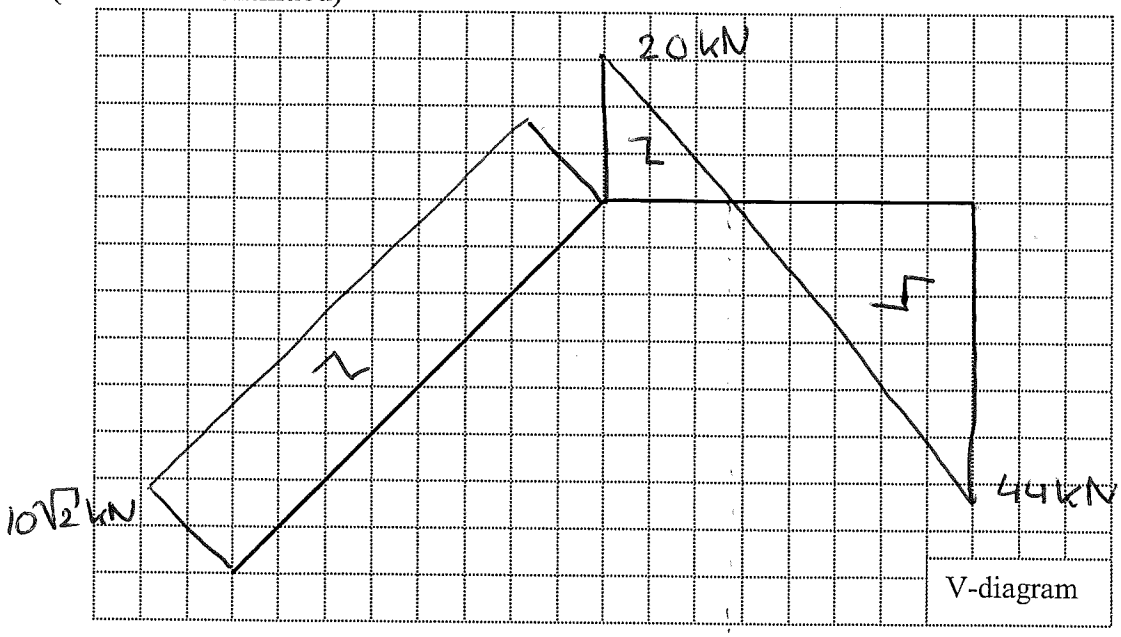
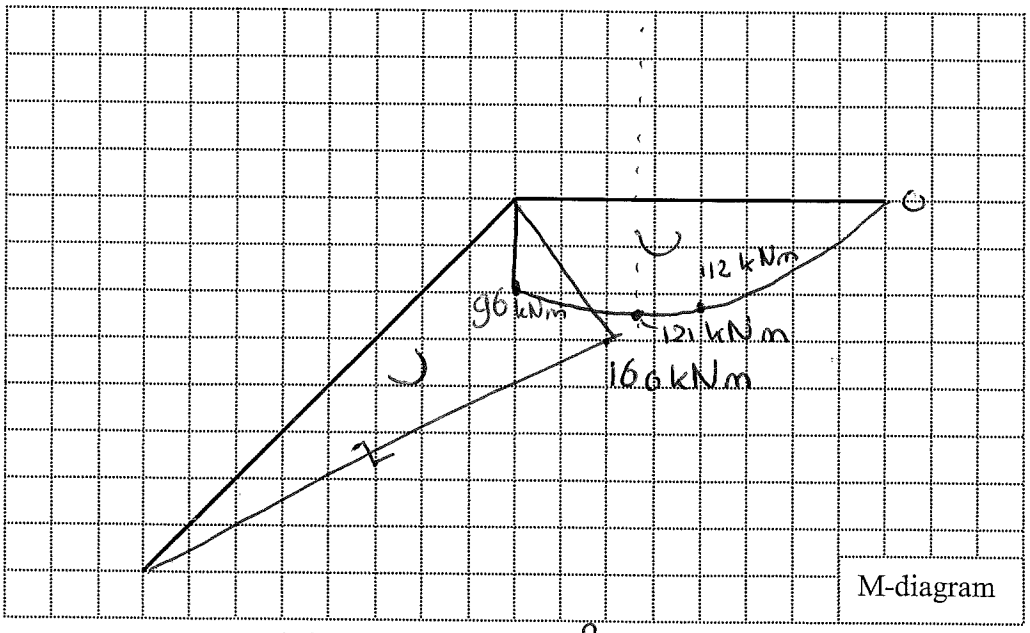
(Problem 4 continued)





x for $M_{max} = \frac{20}{(20+44)} \cdot 8 = \frac{20}{64} \cdot 8 = \frac{80}{32}$ m $= 2\frac{1}{2}$ m from B

$M_{max} = 96 + \frac{1}{2} \cdot 20 \left(\frac{20}{64} \cdot 8\right) = 121$ kNm

Answer sheets | Student no: | | | | | | | |

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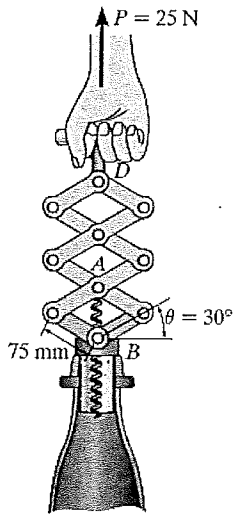
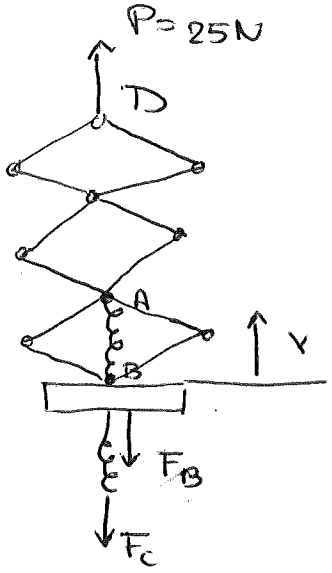
Problem 5 (Weight 1.5 - approx. 30 minutes)

A corkscrew mechanism is used to uncork the bottle in the picture below. A force of P = 25 N is applied to the handle of the mechanism. The screw is attached to the pin at A and passes through the collar that is attached to the bottle neck at B.
Een kurkentrekker wordt gebruikt om een fles ontkurken zoals te zien is in het onderstaande plaatje. Een kracht van P = 25 N wordt uitgeoefend op greep van het mechanisme. De schroef is bevestigd aan de pin in A en gaat door de ring die in B aan de flessenhals is bevestigd.





Questions:

a) Calculate the force the screw exerts on the cork of the bottle, using the principal of virtual work.
Bereken de kracht die de schroef uitoefent op de kurk van de fles, gebruik makend van het principe van virtuele arbeid.

With respect to point B, the position of point A is given by:

$x_A = 2.75 \sin\theta \rightarrow x_A = 150 \sin\theta$

$\delta x_A = 150 \cos\theta \delta\theta$

The position of point D is given by:

$x_D = 6.75 \cdot \sin\theta \rightarrow x_D = 450 \sin\theta$

$\delta x_D = 450 \cos\theta \delta\theta$

(Problem 5 continued)

with F_C = the force exerted by the mechanism on the cork
and F_B = the force exerted by the mechanism on the bottle

$\delta W = 0 : P\delta x_D - F_C \delta x_A - F_B \delta x_B = 0$

$25 \cdot 450 \cos\theta \delta\theta - F_C \cdot 150 \cos\theta \delta\theta - F_B \cdot 0 = 0$

$\rightarrow \delta\theta \neq 0$ & dividing by $\cos\theta$ gives

$25 \cdot 450 - F_C \cdot 150 = 0$

$\rightarrow F_C = 75$ kN (tension)

b) Calculate the force the screw exerts on the bottle.
Bereken de kracht die de schroef op de fles uitoefent.

$\Sigma F_x \uparrow + : 0 = P - F_B - F_C$

$F_B = -50$ N (compression)

Answer sheets Student no:

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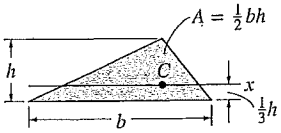
Formula Sheet Moments of Inertia – AE1103 Statics

Only this sheet may be used at the exam!

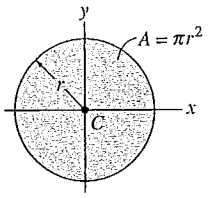
Area Moments of Inertia

Triangle:



$I_x = \frac{1}{36}bh^3$

Circle:

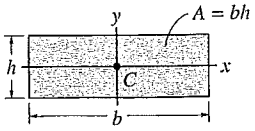


$I_x = \frac{1}{4}\pi r^4$

$I_y = \frac{1}{4}\pi r^4$

$J_C = \pi R^4/2$

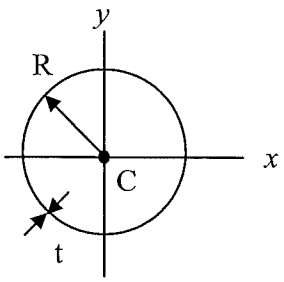
Rectangle:



$I_x = \frac{1}{12}bh^3$

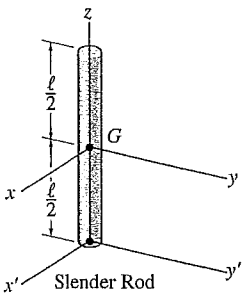
$I_y = \frac{1}{12}hb^3$

Thin-walled ring



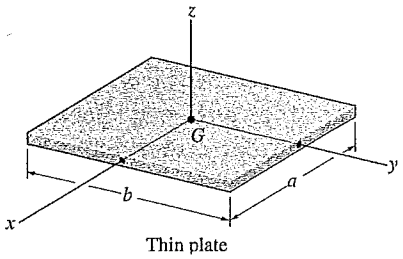
$I_x = \pi R^3 t$;
$I_y = \pi R^3 t$;
$J_C = 2\pi R^3 t$

Mass Moments of Inertia



Slender Rod

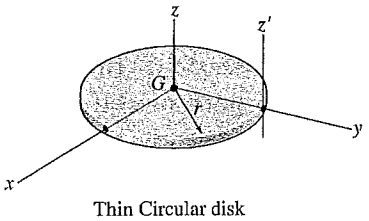
$I_{xx} = I_{yy} = \frac{1}{12}ml^2$



Thin plate

$I_{xx} = \frac{1}{12}mb^2; I_{yy} = \frac{1}{12}ma^2$

$I_{zz} = \frac{1}{12}m\left(a^2 + b^2\right)$



Thin Circular disk

$I_{xx} = I_{yy} = \frac{1}{4}mr^2; I_{zz} = \frac{1}{2}mr^2$