Space above not to be filled in by the student

Delft Applied Mechanics Course
Statics

AE1-914 part I – 27 October 2008 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.

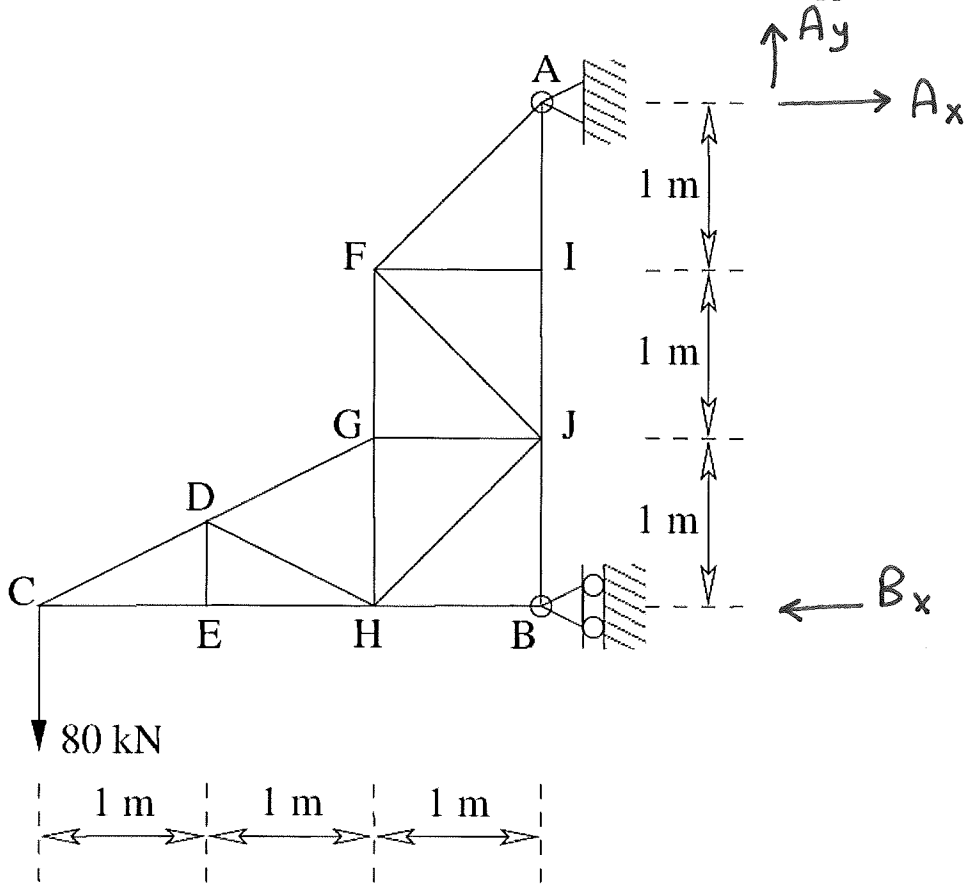
All answers must be given mentioning the correct SI units.

Answer sheets Student no:

Exam Ae1-914 part I Name:

Problem 1 (Weight 2.5 - approx. 40 minutes)

The truss structure given in the figure is loaded by a force of 80 kN in node C.
Gegeven onderstaand vakwerk onder een verticale belasting van 80 kN in knooppunt C.



a) Calculate the reaction forces in the supports A and B.
Bereken de reactiekrachten in de steunpunten A en B.

Answer:

$\curvearrowleft \Sigma M_A = 0 = 80(3) - B_x(3) \curvearrowright B_x = 80\ kN$

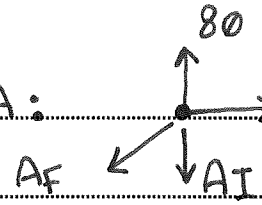
$\Sigma F_x = 0 = -B_x + A_x \curvearrowright A_x = 80\ kN$

$\Sigma F_y = 0 = -80 + A_y \curvearrowright A_y = 80\ kN$

Exam Ae1-914 part I Name:

b) Somebody claims that bar IJ is a zero-force member. Is this correct? Motivate your answer.
Iemand beweert dat staaf IJ een nulstaaf is. Is dat correct? Licht uw antwoord toe.

Answer



• Node A: $\Sigma F_x = 0$

$\Sigma F_y = 0$

$A_F = 80\sqrt{2}$

$A_I = 0$

$\Rightarrow A_I = 0 \rightsquigarrow I_J = 0$

c) Indicate which bars are zero-force members.
Geef alle nulstaven in het vakwerk aan.

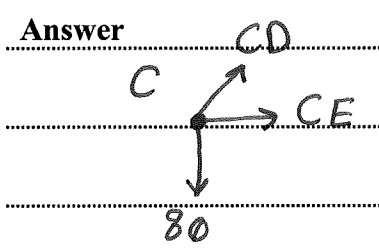
Answer

AI , IJ , FI ; BJ , DE , DH

Exam Ae1-914 part I Name:

d) Calculate the forces in all bars with the correct sign for tension and compression. Collect your results in the table provided on the answer form.
Bereken alle staafkrachten met het juiste teken voor trek- en drukkrachten. Zet uw resultaten in de tabel op dit antwoordformulier.

Answer



$\frac{2}{\sqrt{5}} CD + CE = 0$

$\frac{1}{\sqrt{5}} CD - 80 = 0$

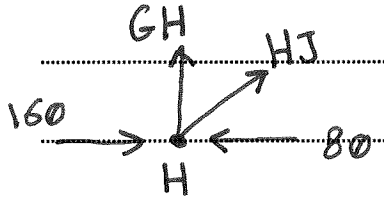
$\Rightarrow CD = 80\sqrt{5}$

$CE = -160$ KN

$\Rightarrow EH = CE$

$DG = CD$

$HB = -B = -80$ KN



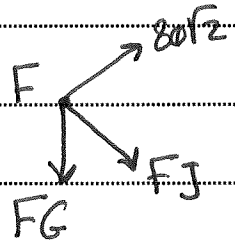
$\Sigma F_x = 0$

$\Sigma F_y = 0$

$HJ = -80\sqrt{2}$ KN

$GH = 80$ KN

$AF = \sqrt{A_x^2 + A_y^2} = 80\sqrt{2}$ KN

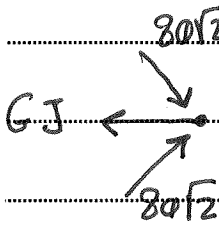


$-FG - FJ \cdot \frac{\sqrt{2}}{2} + 80 = 0$

$80 + \frac{\sqrt{2}}{2} FJ = 0$

$FJ = -80\sqrt{2}$ KN

$FG = 160$ KN



$\Rightarrow GJ = 160$ KN

Answer sheets Student no:

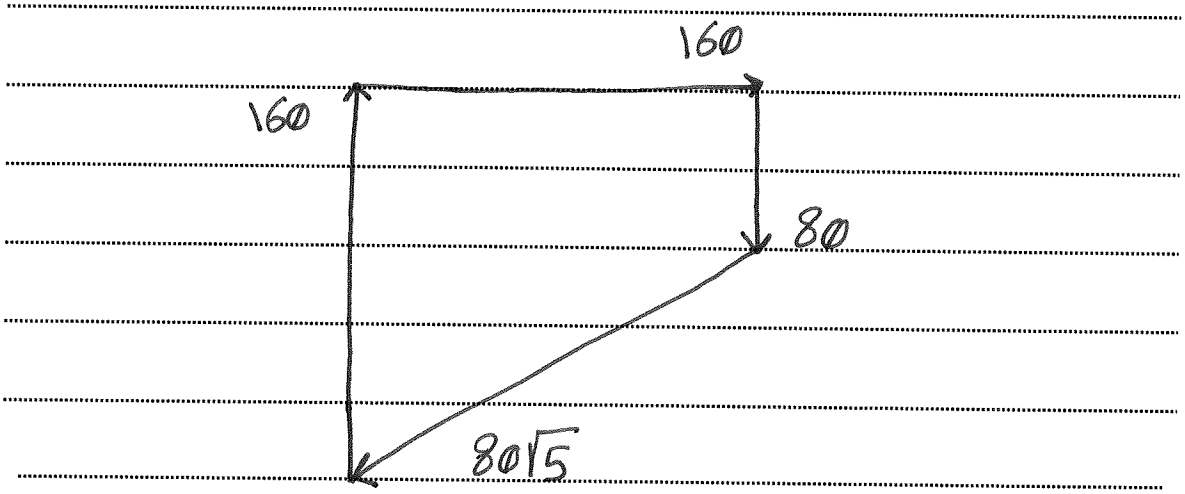
Exam Ae1-914 part I Name:

Bar	Force (in KN)	bar	Force (in KN)
CE	-160	HJ	$-80\sqrt{2}$
CD	$80\sqrt{5}$	BJ	0
DE	0	GJ	160
DG	$80\sqrt{5}$	FG	160
DH	0	FJ	$-80\sqrt{2}$
EH	-160	FI	0
GH	80	AF	$80\sqrt{2}$
BH	-80		
AI	0		

Exam Ae1-914 part I Name:

e) Draw the force polygon for node G.
Teken de krachtenveelhoek voor knooppunt G.

Answer



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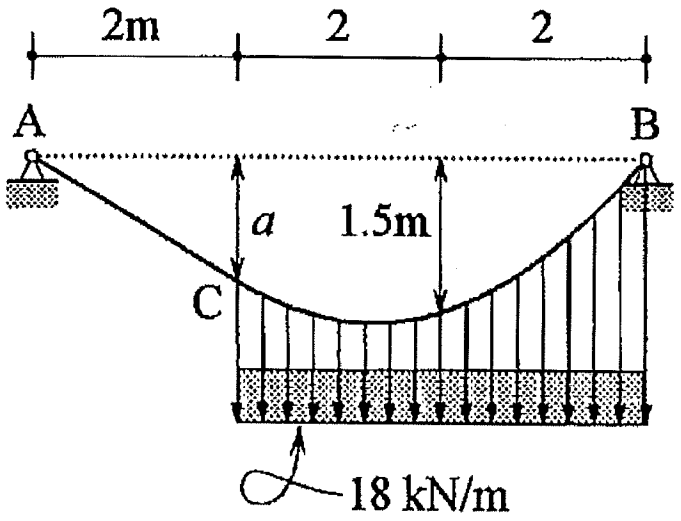
Exam Ae1-914 part I Name:

Problem 2 (Weight 2 - approx. 30 minutes)

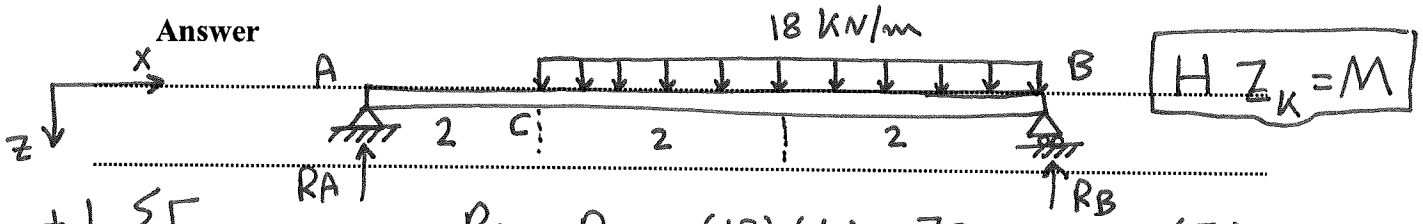
Due to the uniformly distributed load of 18 kN/m on CB, cable AB assumes the shape shown.
Onder invloed van de uniform verdeelde belasting van 18 kN/m op kabeldeel CB krijgt kabel AB de vorm zoals aangegeven in onderstaande figuur.



a) Determine the horizontal component of the cable force.
Bepaal de horizontale component van de kracht in de kabel.

0.5

Answer



$H Z_K = M$

$+\downarrow \sum F_z = 0 \rightarrow R_A + R_B = (18)(4) = 72 \quad \ldots\ldots (I)$

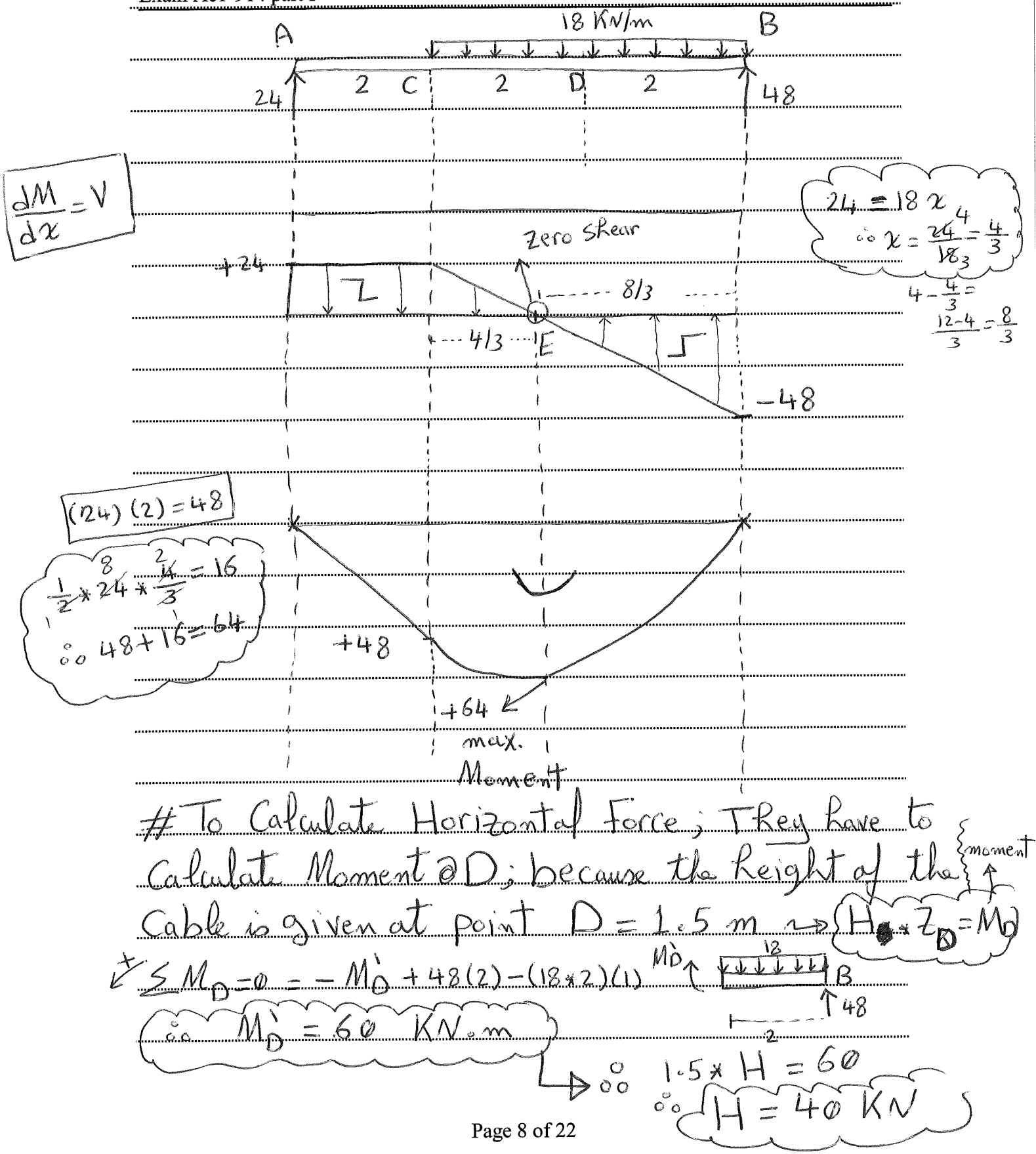
$+\circlearrowleft \sum M_y|_B = 0 \rightarrow -R_A(6) + (18 \times 4)(2) = 0$

$\therefore R_A = 24 \uparrow KN \quad \ldots\ldots (II)$

$\therefore R_B = 72 - 24 = 48$

Answer sheets Student no:

Exam Ae1-914 part I Name:



To Calculate Horizontal Force, They have to Calculate Moment @D; because the height of the cable is given at point D = 1.5 m → $H \cdot z_D = M_D$ (moment)

$+\circlearrowleft \sum M_D = 0 = -M_D' + 48(2) - (18*2)(1)$

∴ $M_D' = 60$ KN.m

∴ $1.5 * H = 60$

∴ $H = 40$ KN

Exam Ae1-914 part I Name:

b) Determine the maximum cable force. 0.5
Bepaal de maximum kabelkracht.

Answer

Max. Cable force (N) is at where the slope of Cable is Max. → at 'B'

$\therefore N_{max} = \sqrt{H^2 + V_B^2} = \sqrt{(40)^2 + (48)^2}$

$N_{max} = 62.48 \text{ kN}$

c) Determine the support reactions at A and B. 0.25
Bepaal de steunpuntreacties in A en B.

Answer

From Solution of part (a)

$R_A = 24$; $R_B = 48$

Exam Ae1-914 part I Name:

d) Determine the sag at C.
Bepaal de doorhang van de kabel in punt C.

0.5

Answer

To Determine Sag at 'C', Simply apply the Same Eqn. → $H_c * Z_c = M_c$

as H = Constant along all cable = 40

∴ $40 * Z_c = 48$ → From moment diagram at part (a)

∴ $Z_c = 1.2$

e) Determine the maximum sag of the cable.
Bepaal de maximale doorhang van de kabel.

0.25

Answer

Max Sag is at the point Where moment is maximum [Check moment Diagram]

$M_{max} = 64$ ✓ and We KnoW H = Const = 40

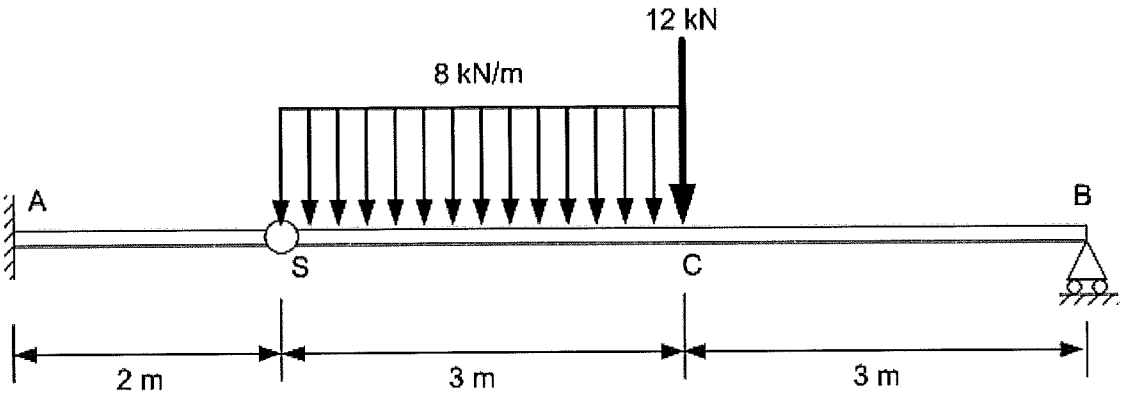
∴ $40 * Z_{max} = 64$

∴ $Z_{max} = 1.6$

Answer sheets Student no:

Exam Ae1-914 part I Name:

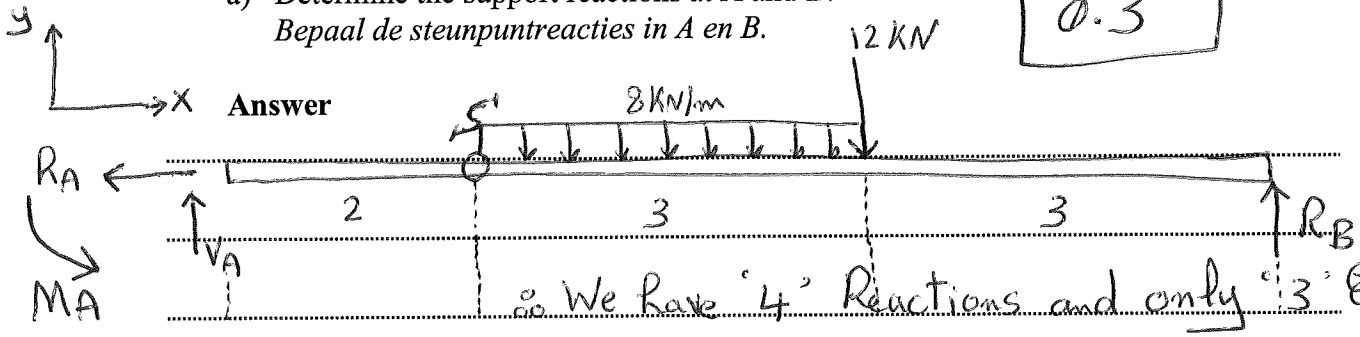
Problem 3 (Weight 1 - approx. 30 minutes)



a) Determine the support reactions at A and B.
Bepaal de steunpuntreacties in A en B.

0.3

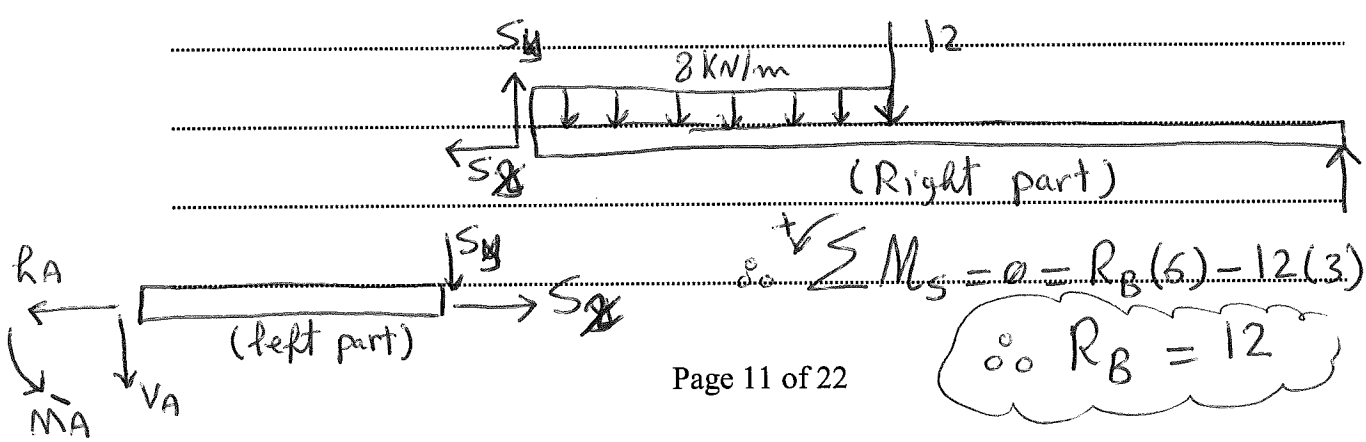
Answer



∴ We Have '4' Reactions and only '3' Equilprium Eqns.

∴ We Have Extra Reaction (statically Indeterminant)

but We Have Joint at 'S' Which gives us an Extra Eqn. that Moment = Zero @ S for the left part and the Right part.



$+\circlearrowleft \sum M_S = 0 = R_B(6) - 12(3) - (8*3)(1.5)$

∴ $R_B = 12$

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Exam Ae1-914 part I Name:

[Right part]: $\rightarrow +\sum F_x = 0 \rightsquigarrow S_x = 0$; $+\uparrow \sum F_y = 0 \rightsquigarrow S_y = 24+12-12 = 24$

[Left part]: $\sum F_x = 0 \rightsquigarrow h_A = 0$; $\sum F_y = 0 \rightsquigarrow V_A = -24$

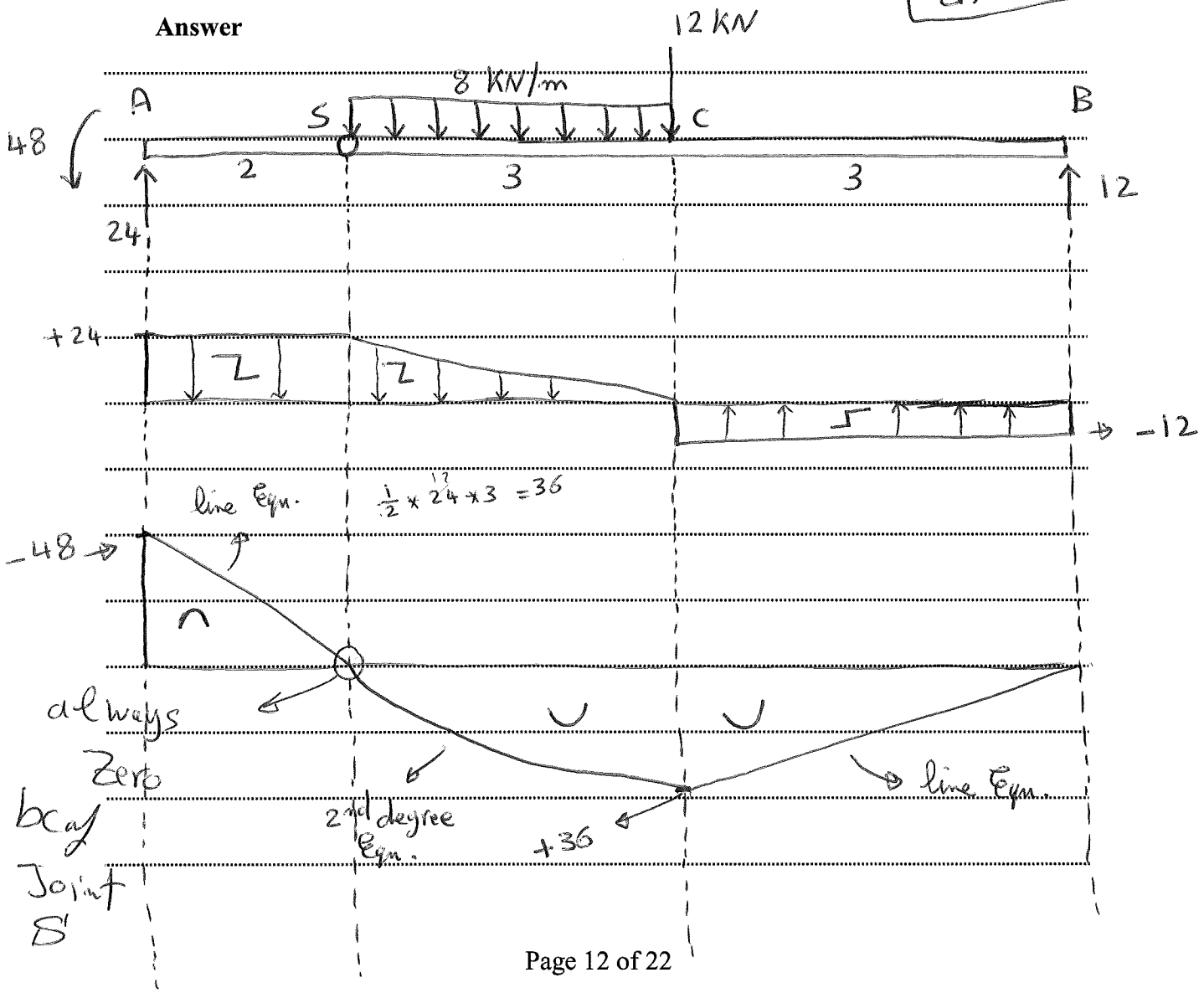
$+\circlearrowleft \sum M_A = 0 \rightsquigarrow M_A' - 24(2) = 0$ $\therefore M_A' = 48$

$\therefore h_A = 0$; $V_A = -24$; $M_A = 48$; $R_B = 12$

b) Draw the V and M diagrams for the entire structure. @.5
Teken de V- en M-lijnen voor de gehele constructie.

$\frac{dM}{dx} = V$

Answer



Answer sheets Student no:

Exam Ae1-914 part I Name:

c) Determine the location and magnitude of the maximum bending moment. @.2
Bepaal de positie en de grootte van het maximale buigend moment.

Answer

x at A → $M_{max} = 48$

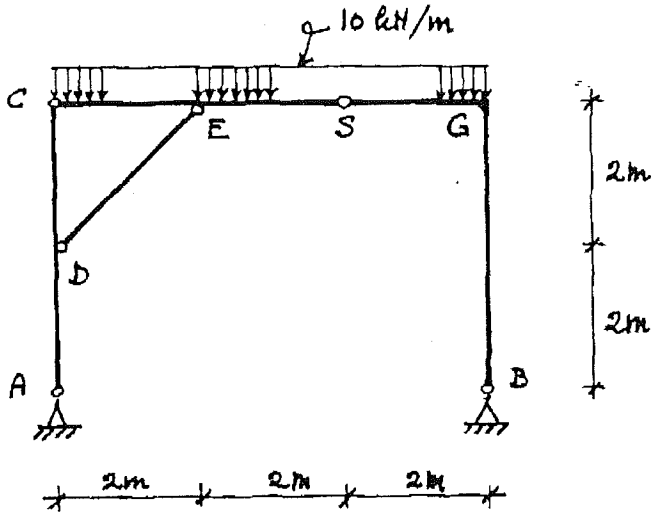
If They got Reaction $M_A = 48$ Correct
and They wrote $M_{max} = 36$ @6, then
Give Them @.1 mark

Answer sheets Student no:

Exam Ae1-914 part I Name:

Problem 4 (Weight 2.5 - approx. 45 minutes)

A shored three-hinged frame with a uniformly distributed full load of 10 kN/m on the girder CESG is given.
Een geschoord (ondersteund) driescharnierenspant wordt belast met een uniform verdeelde belasting van 10 kN/m op de ligger CESG.

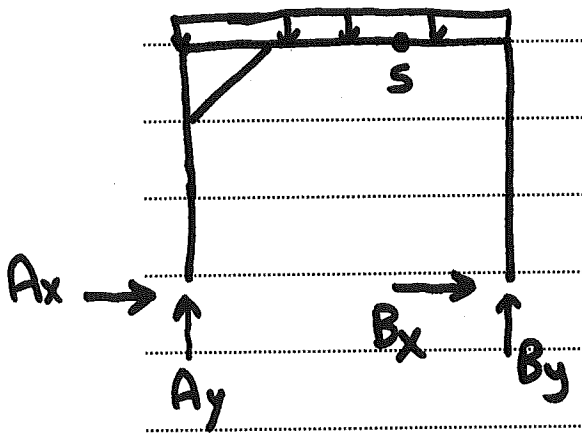


a) Determine the support reactions at A and B.
Bepaal de steunpuntreacties in A en B.

Answer

$\curvearrowleft + \sum T_z|_B = 0 = -A_y \cdot 6 + 60 \cdot 3$

$\rightsquigarrow A_y = 30\ KN$



$\curvearrowleft + \sum T_z|_A = 0 = B_y \cdot 6 - 60 \cdot 3$

$\rightsquigarrow B_y = 30\ KN$

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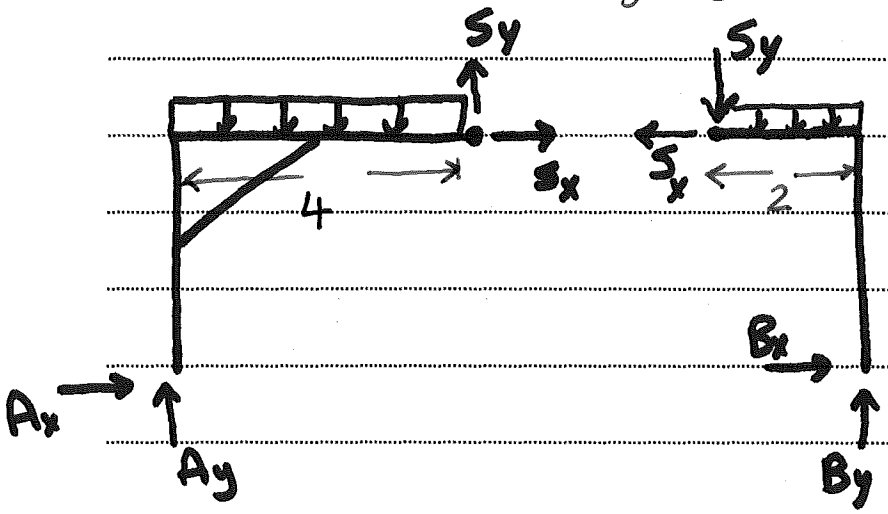
make a section through joint "S":



(Left part) $\overset{+}{\curvearrowleft} \sum T_z|_S = 0 = (40) * 2 - A_y * 4 + A_x * 4$

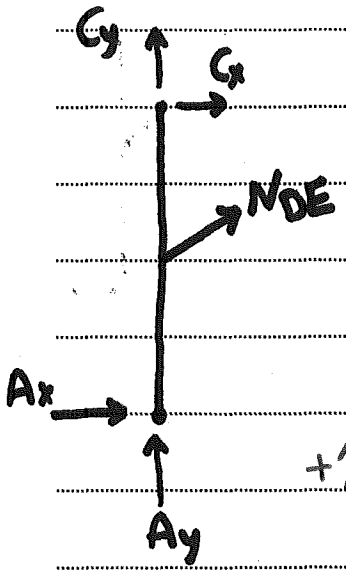
$\rightsquigarrow A_x = 10 \text{ KN}$

(Right part) $\overset{+}{\curvearrowleft} \sum T_z|_S = 0 = -20 * 1 + B_y * 2 + B_x * 4$

$\rightsquigarrow B_x = -10 \text{ KN}$

b) Determine the force in shore DE, with the correct sign.
Bepaal de kracht in staaf DE, met het juiste teken.

Answer



$\curvearrowleft + \sum M_C = 0$

$A_x \times 4 + \frac{1}{2}\sqrt{2} \times N_{DE} \times 2 = 0$

$\curvearrowright N_{DE} = -20\sqrt{2}$ KN

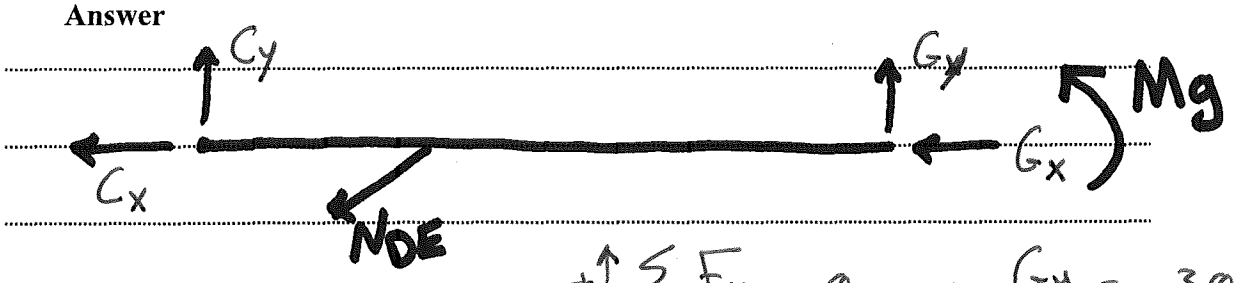
$+\uparrow \sum F_y = 0 = A_y + \frac{1}{2}\sqrt{2} \times N_{DE} + G_y$

$\curvearrowright C_y = -10$ KN

$+\uparrow \sum F_x = 0 \curvearrowright C_x = 10$ KN

c) Draw N, V, and M diagrams for CESG.
Teken de N-, V- en M-lijnen voor ligger CESG.

Answer



$+\uparrow \sum F_y = 0 \curvearrowright G_y = -30$

$\pm\rightarrow \sum F_x = 0 \curvearrowright G_x = -10$

$\curvearrowleft + \sum T_{z|G} = 0 \curvearrowright M_g = 40$ KN.m

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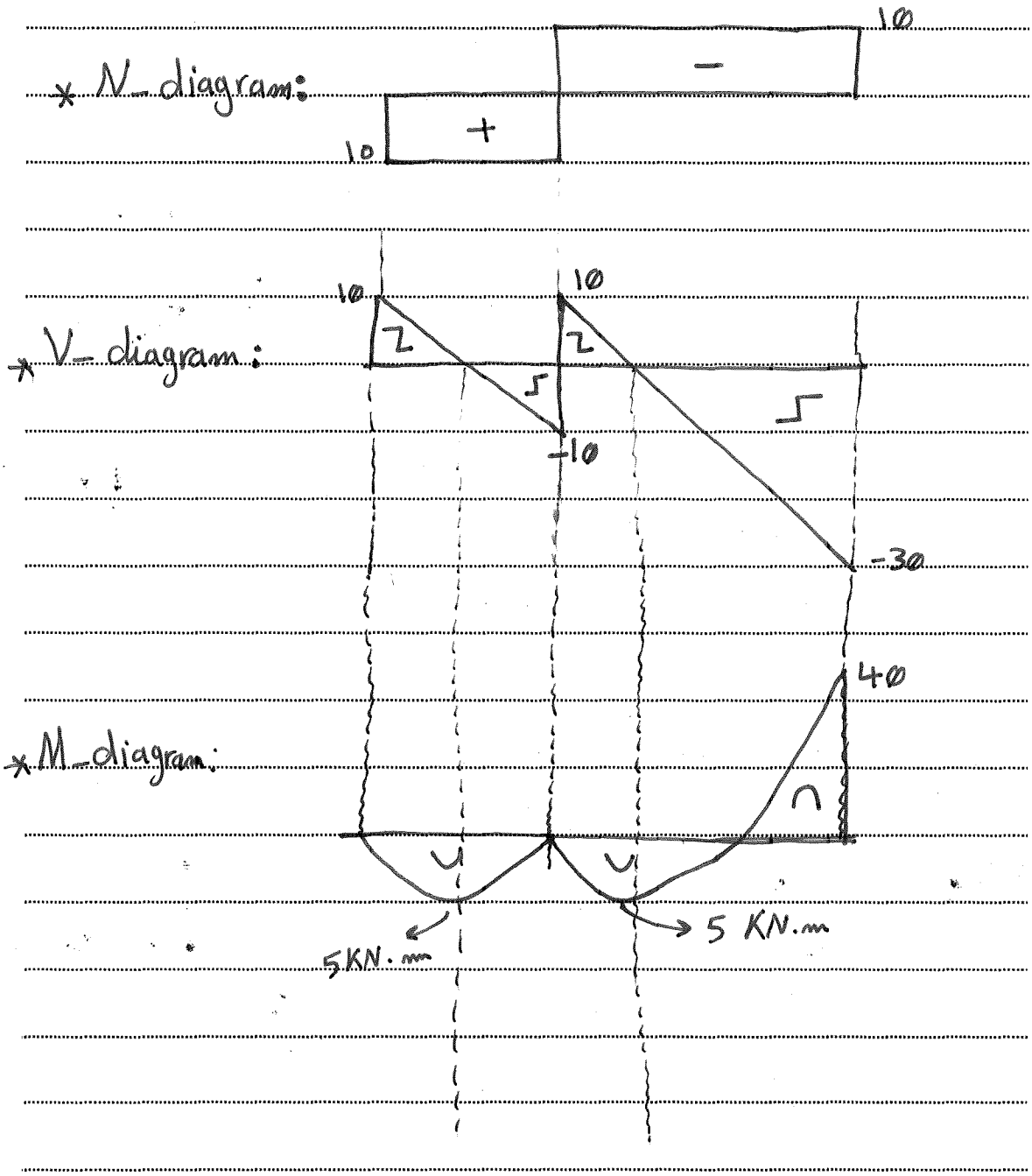
Exam Ae1-914 part I Name:



d) Determine the location and magnitude of the extreme moments in CESG.
Bepaal de positie en de grootte van de extreme momenten in CESG.

Answer

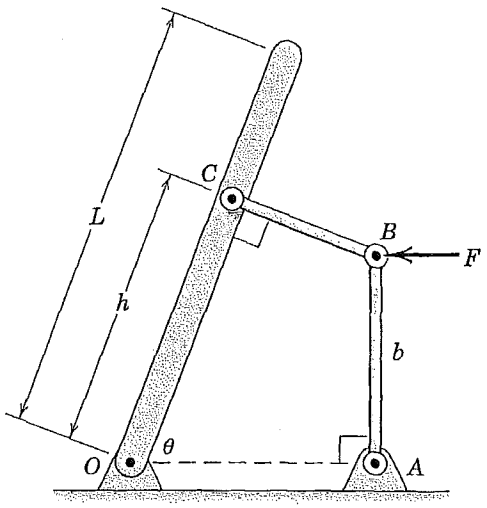
Extreme at point G = 40 KN.m

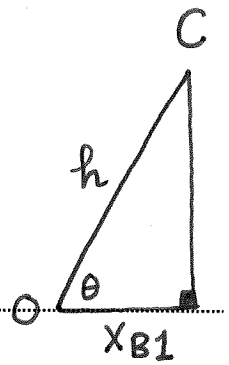
Answer sheets Student no:

Exam Ae1-914 part I Name:

Problem 5 (Weight 2 - approx. 35 minutes)

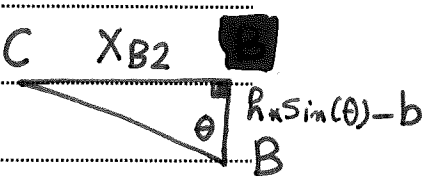
a) The uniform bar of mass m is held in the inclined position θ by the horizontal force F applied to the links AB and BC whose masses are negligible. For the position shown AB is perpendicular to AO and BC is perpendicular to the bar, determine F. Use the principle of virtual work.
Onder invloed van een horizontale kracht F wordt de uniforme balk met massa m in een positie θ gehouden. Een horizontale kracht F grijpt aan in punt B, waar de massaloze staven CB en AB scharnierend met elkaar zijn verbonden. Voor de getekende positie staat staaf AB loodrecht op AO en staat staaf CB loodrecht op de uniforme balk. Bereken, met het principe van virtuele arbeid, de kracht F die nodig is om de balk in de getekende positie te houden.





$X_B = X_{B1} + X_{B2}$

$X_{B1} = h \times \cos(\theta)$



$X_{B2} = [h \times \sin(\theta) - b] \times \tan(\theta)$

Exam Ae1-914 part I Name:

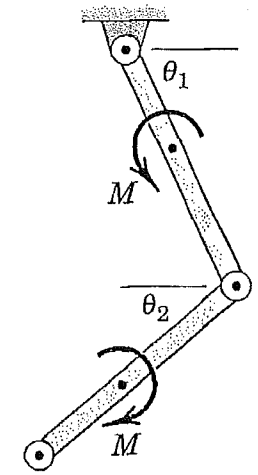
$$\therefore \delta x_B = -h * \sin(\theta) * \delta\theta$$

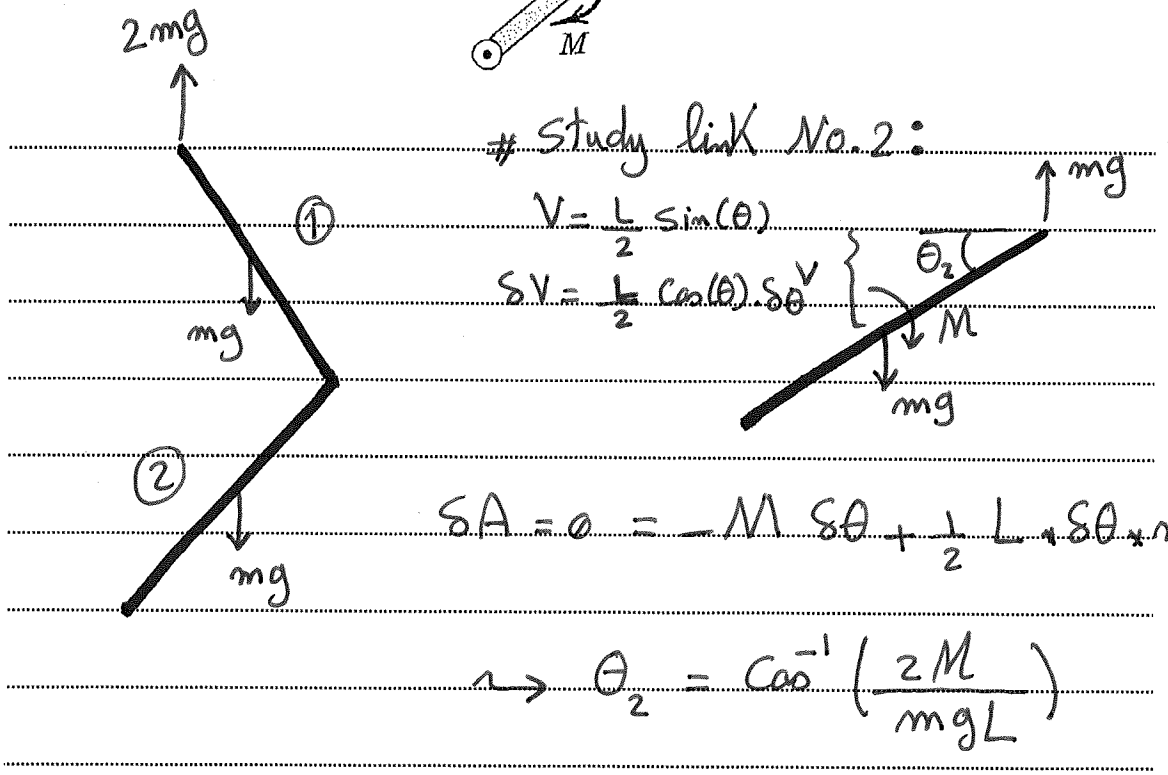
$$\therefore \delta A = F * \delta x_B + mg\left[\frac{-L}{2} * \cos(\theta)\right] = 0$$

$$\therefore F = \frac{-1}{2} * \frac{mgL}{h} * \frac{\cos(\theta)}{\sin(\theta)}$$

Exam Ae1-914 part I Name:

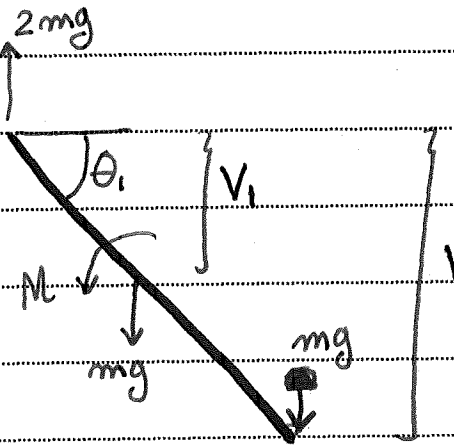
b) Each of the uniform identical links has a length *l* and mass *m* and is subjected to a couple M, one clockwise and the other counterclockwise, applied as shown. Determine the angle which each link makes with the horizontal when the system is in its equilibrium configuration. Use the principle of virtual work.
Elk van de uniforme balken heeft lengte l en massa m. Beide balken worden belast met een moment M, zoals in onderstaande figuur. Bepaal de hoek die elke balk maakt met de horizontaal voor de getekende evenwichtpositie. Gebruik het principe van virtuele arbeid.





Answer sheets Student no:

Exam Ae1-914 part I Name:



$V_1 = \frac{L}{2} * \sin\theta_1$

$V_2 = L * \sin\theta_1$

$\therefore \delta V_1 = \frac{L}{2} \cos(\theta_1)\,\delta\theta_1$

$\delta V_2 = L * \cos(\theta_1)\,\delta\theta_1$

$\delta A = 0 = -M\delta\theta + mg * \frac{L}{2}\cos(\theta_1)\delta\theta + mg * L\cos(\theta_1)\delta\theta$

$\therefore \rightarrow \theta_1 = \cos^{-1}\left(\frac{2M}{3mgL}\right)$