5. Přednáška

Lomené nosníky s se svislými a vodorovnými pruty

Specifika oproti vodorovným nosníkům

- Každý prut má svůj lokální souřadný systém, (systém se volí tak, že osa prutu je totožná s lokální osou x´ a lokální osa y´ je totožná s globální osou y)
- Pravidla pro určení kladných směrů působení vnitřních sil na průřez a pravidla pro způsob vykreslování se řídí lokálním souřadným systémem prutů
- diferenciální podmínky rovnováhy a jejich integrální tvary jsou funkcí souřadnice x´
- na styku dvou a více prutů, které nejsou v přímce nejsou definovány vnitřní síly - je třeba stanovit je pro řezy všech stýkajících se prutů vedené těsně vedle tohoto styku
- normálové síly nelze vyšetřovat odděleně od posouvajících sil a momentů (tato možnost platí pouze pří řešení dílčích přímých částí prutu)

Pozn: různou volbou lokálního souřadného systému se docílí:

- různá znaménka ohybových momentů, pravidlo o vykreslování momentů na stranu tažených vláken tím však dotčeno není.

- Posouvající a normálové síly mají nezměněné znaménko, pouze jsou vykresleny na opačné straně

$$Q = \frac{12 \cdot 5}{2} = 30 \text{ kN}$$

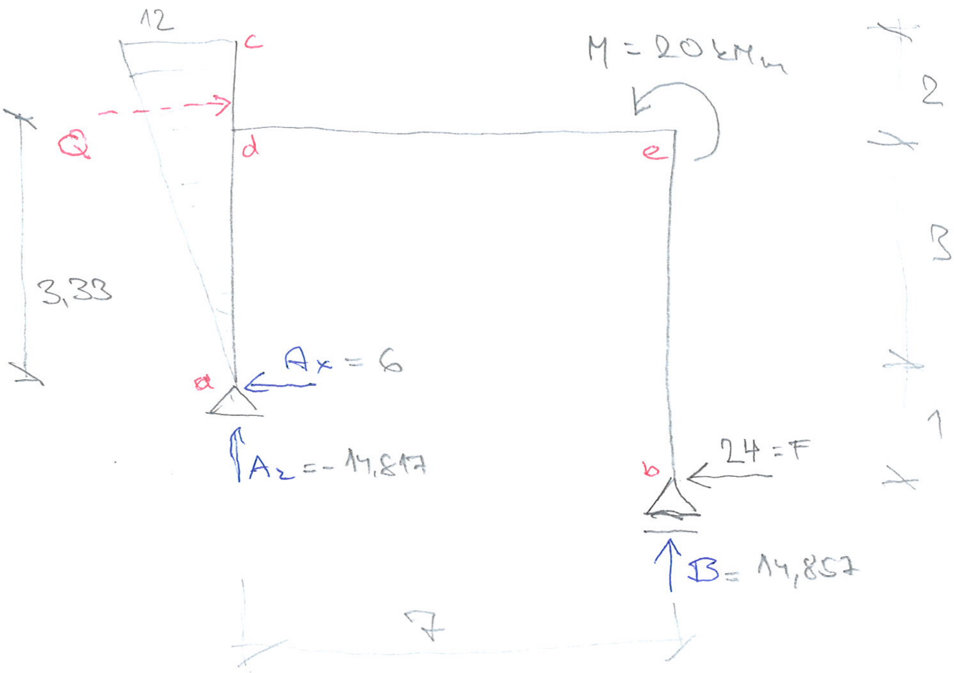
$$A_x = Q - F = 6$$

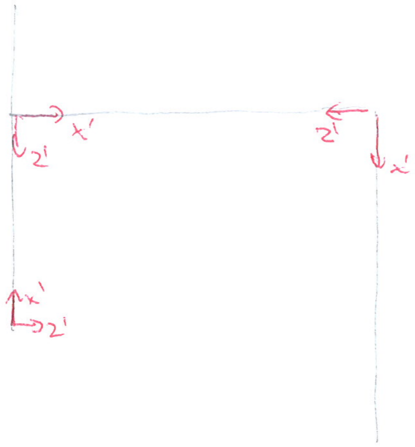
$$+Q \cdot 3{,}33 - M + F \cdot 1 - B \cdot 7 = 0$$

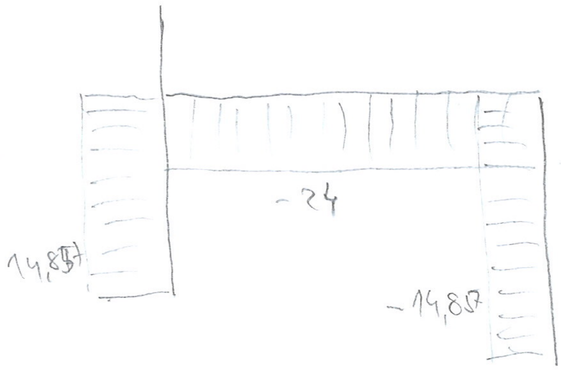
$$B = \frac{30 \cdot 3{,}33 - 20 + 24}{7} = 14{,}857$$

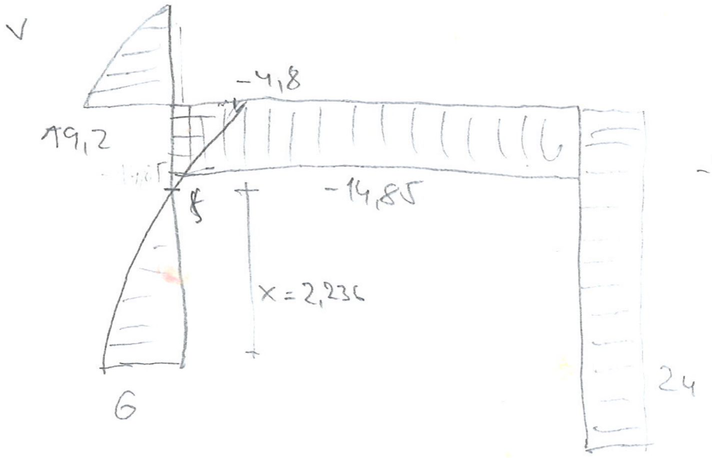
$$-7 A_z + A_x \cdot 1 - Q \cdot 4{,}33 + M = 0$$

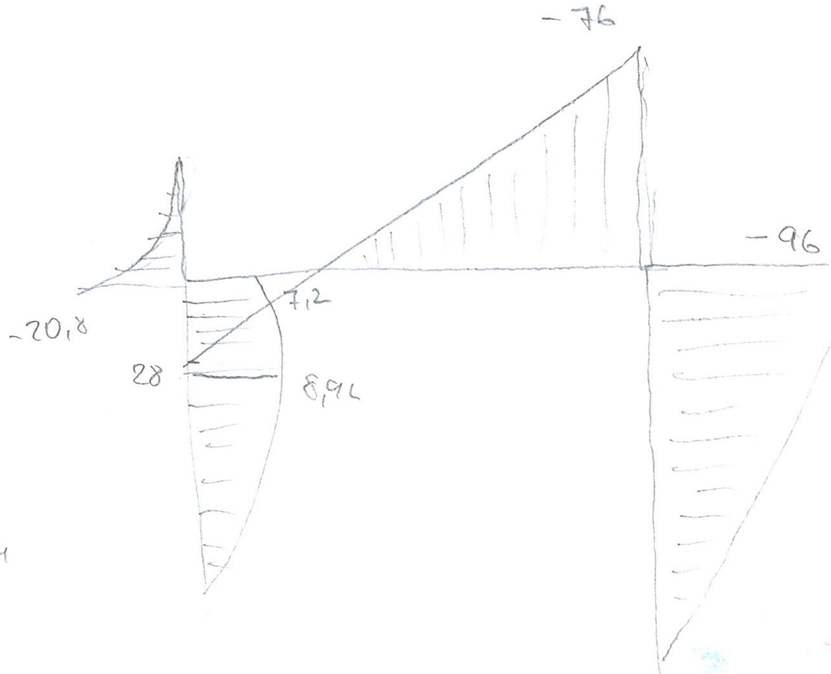
$$A_z = \frac{6 \cdot 1 - 30 \cdot 4{,}33 + 20}{7} = -14{,}81$$

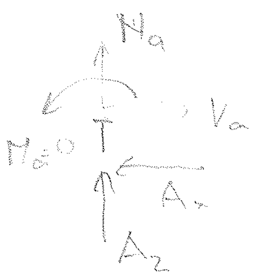






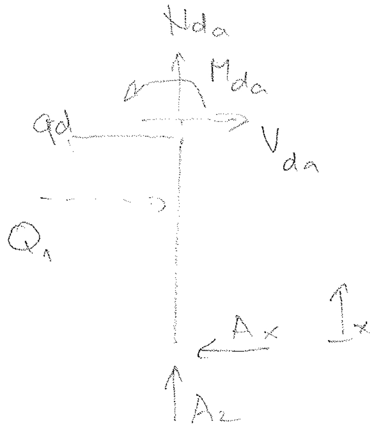






$N_a = -A_z = 14{,}857$

$V_A = A_x = 6$



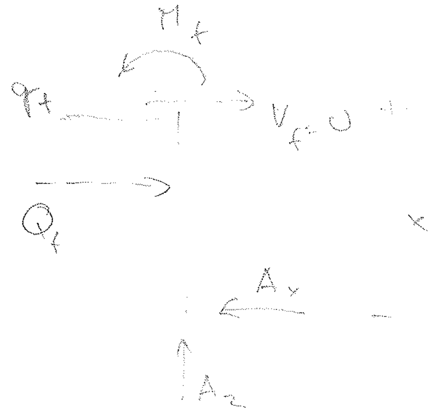
$q(x') = \frac{12}{5}x$

$q_d = \frac{12}{5}3 = 7{,}2$

$Q_1 = \frac{7{,}2 \cdot 3}{2} = 10{,}8$

$V_{da} = A_x - Q_1 = -4{,}8$ kN

$M_{da} = 3 \cdot A_x - Q_1 \cdot 1 = 7{,}2$ kNm



$q_f = \frac{12}{5}x$

$Q_f = \frac{12}{5}x \frac{x}{2} = 1{,}2x^2$

$\Sigma F_{z'i} = 0 \qquad A_x - Q_f = 0$

$1{,}2x^2 = 6$

$x = 2{,}236$

$M_f = A_x x - Q_f \cdot \frac{x}{3} = 8{,}944$

ALTERNATIVNĚ:

$q = \frac{12}{5}x$

$V = \int -q\,dx + C = -\frac{12}{5}x^2 + C$

$V_{(x=0)} = 6 \Rightarrow C = 6$

$V = -\frac{12}{10}x^2 + 6$

$V = 0 \Rightarrow x = 2{,}236$

$M = \int V dx + C = \int(-\frac{12}{10}x^2 + 6)dx + C$

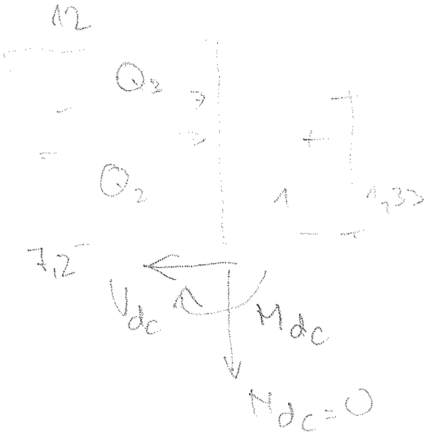
$M = -\frac{12}{30}x^3 + 6x + C$

$M_{(x=0)} = 0$

$\Rightarrow C = 0$

$M = -0{,}4x^3 + 6x$

$M_{(x=2,236)} = 8{,}944$

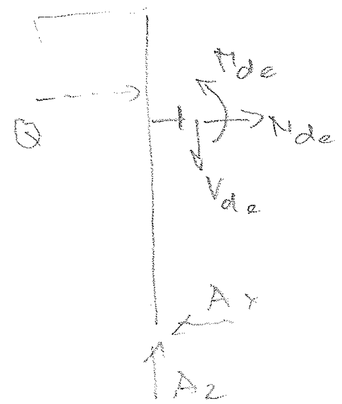


$Q_2 = 7{,}2 \cdot 2 = 14{,}4$

$Q_3 = \frac{(12-7{,}2)\cdot 2}{2} = 4{,}8$

$V_{dc} = Q_2 + Q_3 = 19{,}2$

$M_{dc} = -Q_2 \cdot 1 - Q_3 \cdot 1{,}33 = -20{,}8$

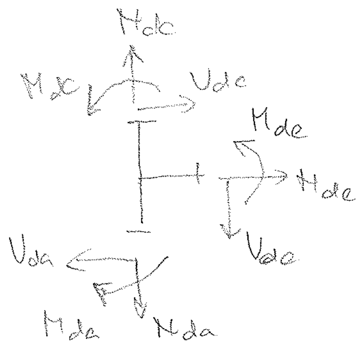


$N_{de} = -Q + A_x = -24$ kN

$V_{de} = A_z = -14{,}857$ kN

$M_{de} = Q \cdot 0{,}33 + A_x \cdot 8 = 28$

ALTERNATIVNĚ



$N_{de} = V_{da} - V_{dc} = -4{,}8 - 19{,}2 = -24$

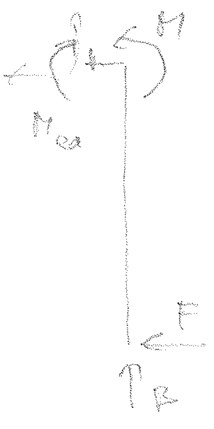
$V_{de} = -N_{da} + N_{dc} = -14{,}857 + 0 = -14{,}857$

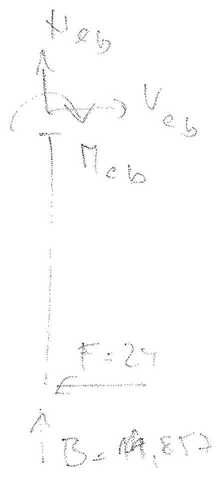
$M_{de} = M_{da} - M_{dc} = 7{,}2 + 20{,}8 = 28$

$M_{ed} = M_{de} + V_{de} \cdot 7 = -76{,}00$

ALTERNATIVNĚ

$M_{ed} = M - F \cdot 4 = -76$



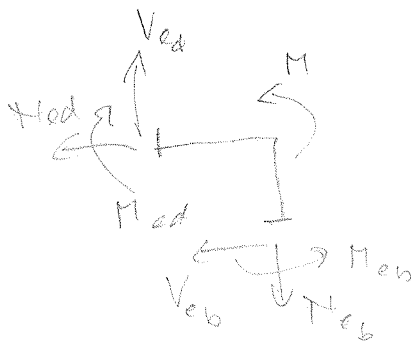


$N_{eb} = -B = -14,857$

$V_{eb} = F = 24$

$M_{eb} = -F \cdot 4 = -96$

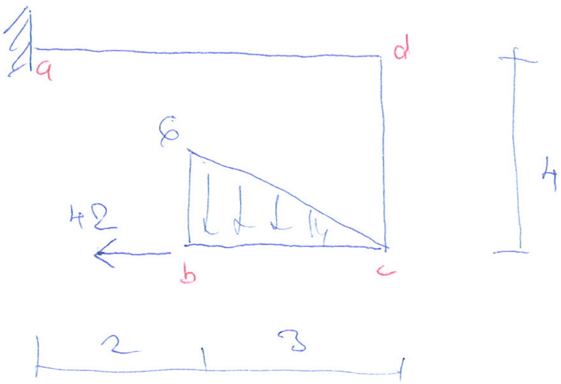
ALTERNATIVNE MENO KONTROLA

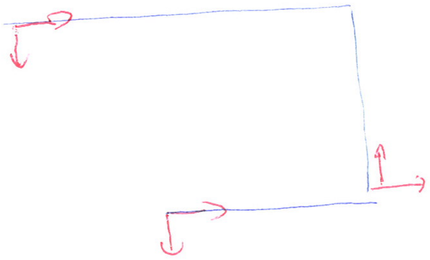


$V_{eb} = -N_{ed} = 24$

$N_{eb} = V_{ed} = -14,85$

$M_{eb} = M_{ed} - M = -76 - 20 = -96$





$M_{cb} = -9 \cdot 2 = -18$

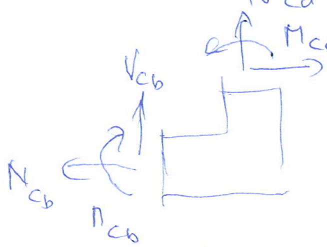
$N_{cb} = +42$

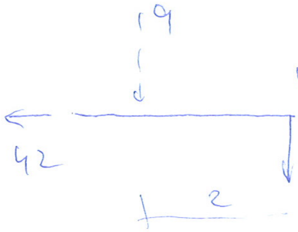
$V_{cb} = -9$

$N_{cd} = -V_{cb} = +9$

$M_{cd} = M_{cb} = -18$

$V_{cd} = N_{cb} = +42$

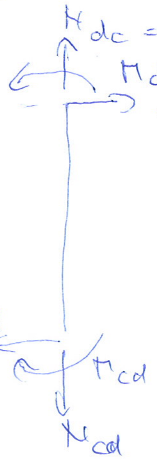


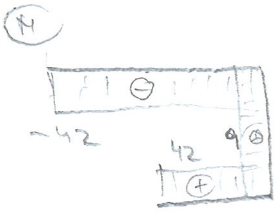


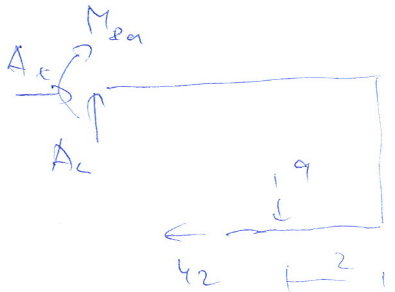
$N_{dc} = N_{cd} = 9$

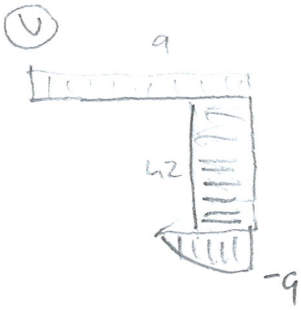
$M_{dc} = M_{cd} + V_{cd} \cdot 4 = -18 + 4(+42) = 150$

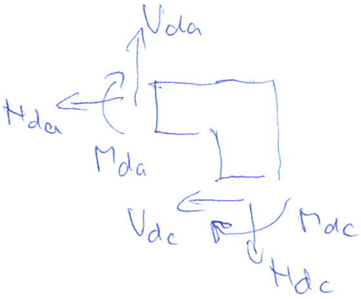
$V_{dc} = V_{cd} = +42$











$A_x = 42$

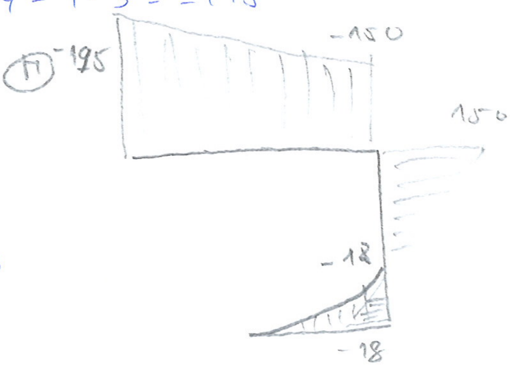
$A_z = 9$

$M_{Ra} = -42 \cdot 4 - 9 \cdot 3 = -195$

$N_{da} = -V_{dc} = -42$

$V_{da} = N_{dc} = 9$

$M_{da} = -M_{dc} = -150$

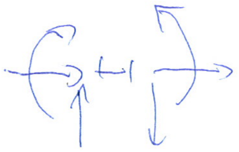


KONTROLA

$N_a = N_{da} = -42$

$V_a = V_{da} = 9$

$M_a = M_{da} - V_{da} \cdot 5 = -150 - 9 \cdot 5 = -195$

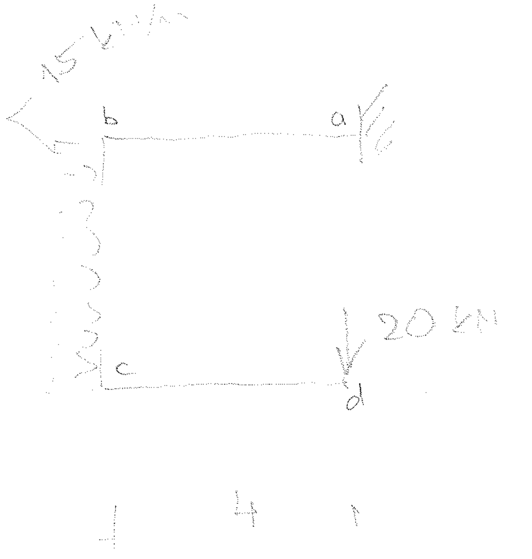


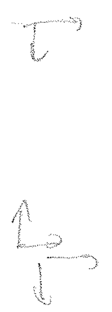
$A_x + N_a = 42 - 42 = 0$

$A_z - V_a = 9 - 9 = 0$

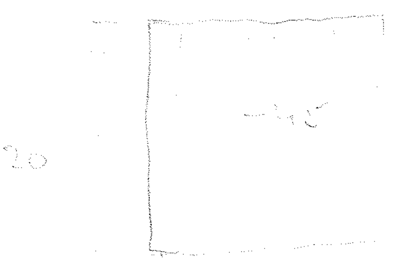
$M_{Ra} - M_a = -195 - (-195) = 0$

T 3.1 a

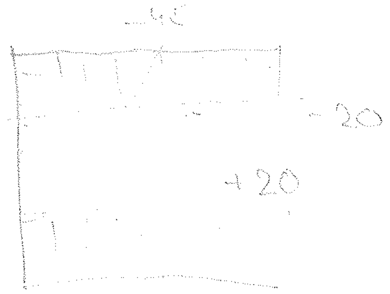




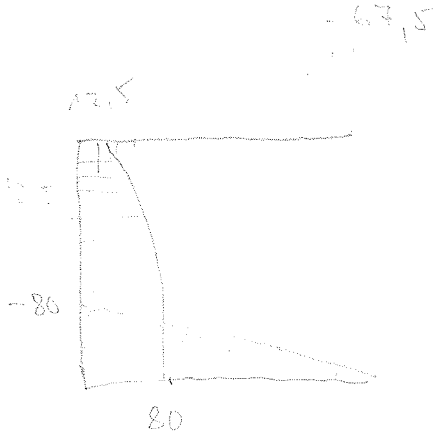
(H)

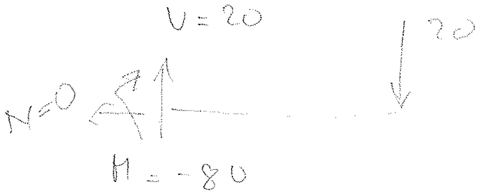


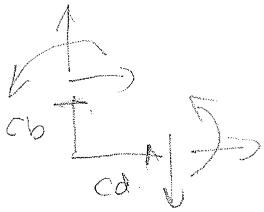
(V)



(M)



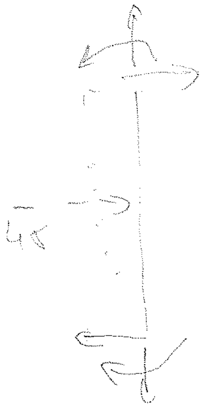




$N_{cb} = V_{cd} = 20$

$V_{cb} = -N_{cd} = 0$

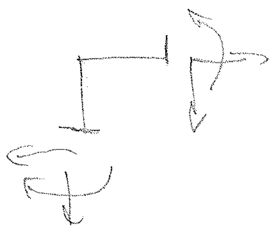
$M_{cb} = -M_{cd} = 80$



$N_{bc} = N_{cb} = 20$

$V_{bc} = V_{cb} - 45 = -45$

$\ast\ M_{bc} = M_{cb} + \overset{0}{V_{cb}} \cdot 3 - 45 \cdot 1{,}5 = 12{,}5$



$N_{ba} = V_{bc} = -45$

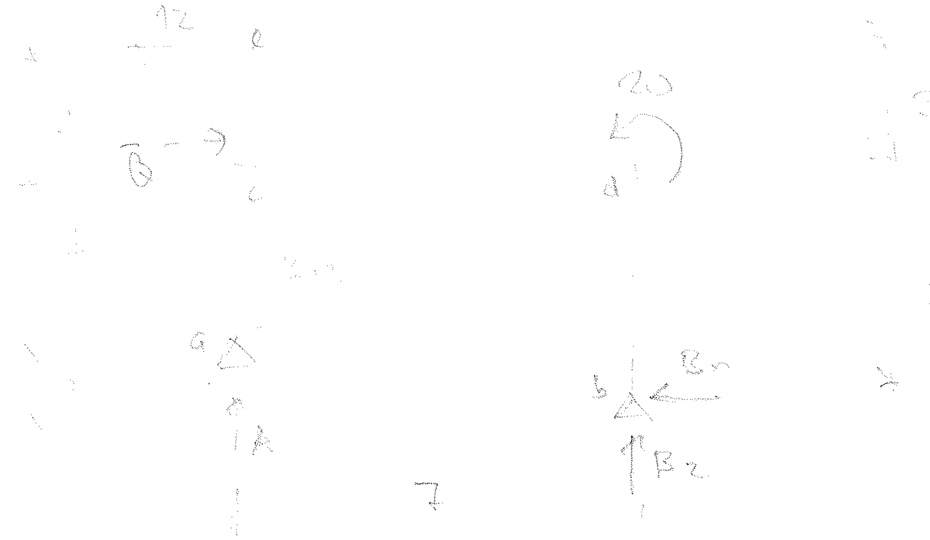
$V_{ba} = -N_{bc} = -20$

$M_{ba} = M_{bc} = 12{,}5$

$N_a = N_{bc}$

$V_a = V_{bc}$

$M_a = M_{bc} + V_{bc} \cdot 4 = 12{,}5 - 80 = -67{,}5$



$Q = \frac{12 \cdot 5}{2} = 30$

$B_x = 30$

$-A \cdot 7 - Q \cdot 4{,}33 + 20 = 0$

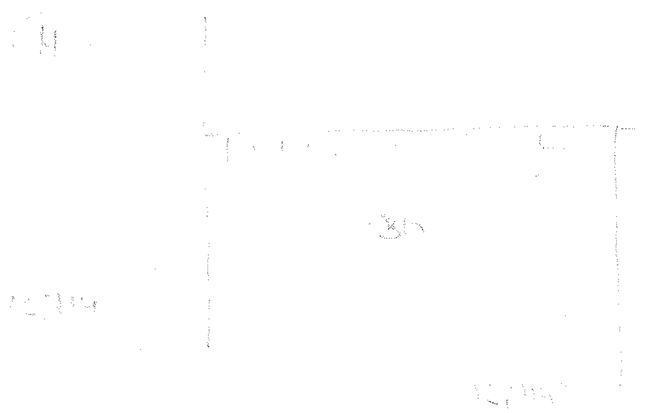
$A = \frac{-30 \cdot 4{,}33 + 20}{7}$

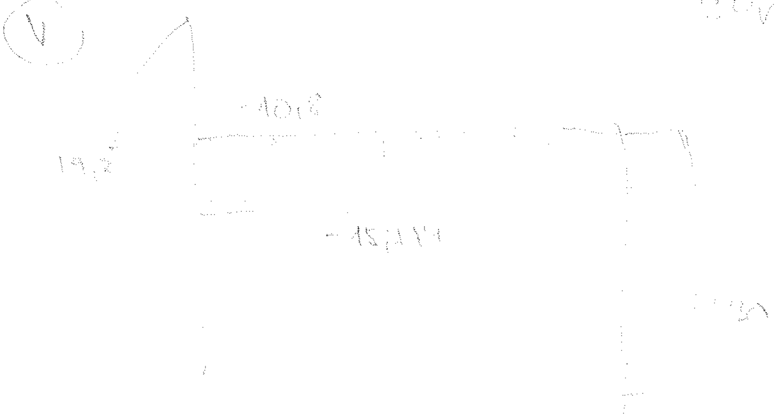
$A = -15{,}914$

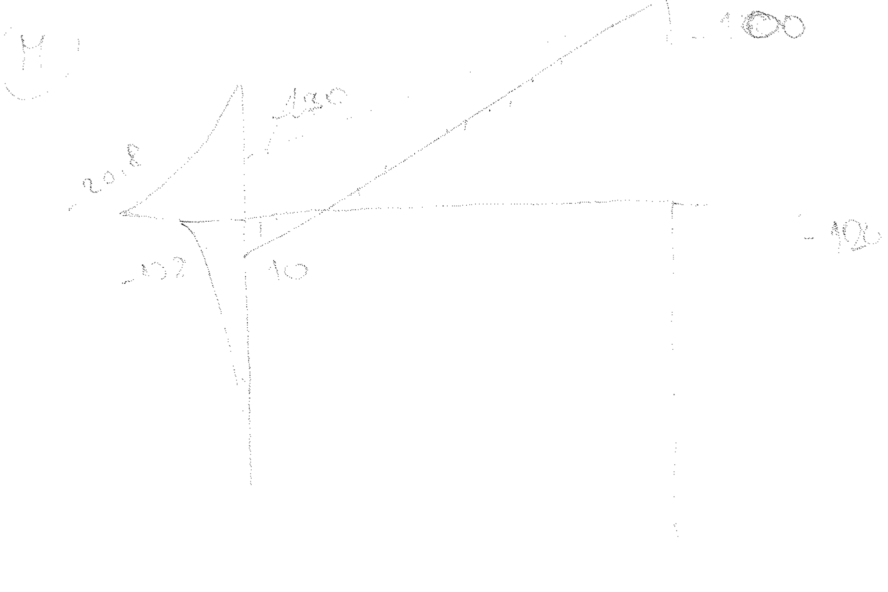
$B_z = 15{,}914$

$q_1 = \frac{12}{5} \cdot 3 = 7{,}2$

$Q_1 = \frac{7{,}2 \cdot 3}{2} = 10{,}8$





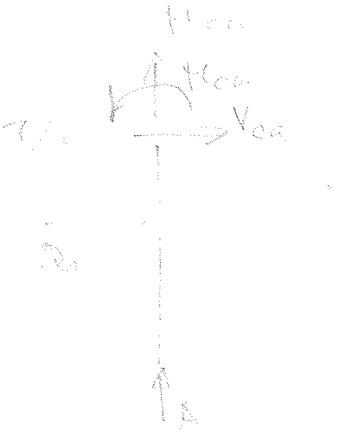


$M_{ce} = -14{,}4 \cdot 1 - 4{,}8 \cdot 1{,}33$

$= -20{,}8$

$M_{cd} = 20 + 15{,}914 \cdot 2 - 4 \cdot 30$

$= 10$

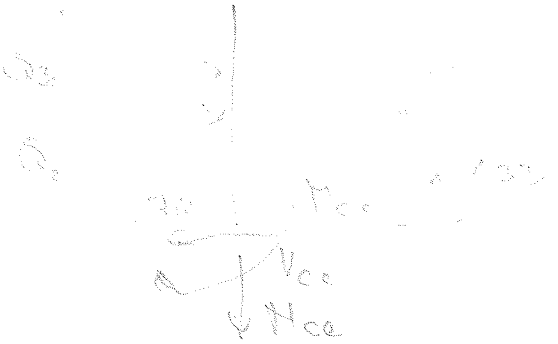


$Q_1 = 7{,}2 \cdot$ [illegible] $= 10{,}8$

$H_{ca} = -A = 15{,}714$

$V_{ca} = -Q_1 = -10{,}8$

$M_{ca} = -Q_1 \cdot 1 = -10{,}8$



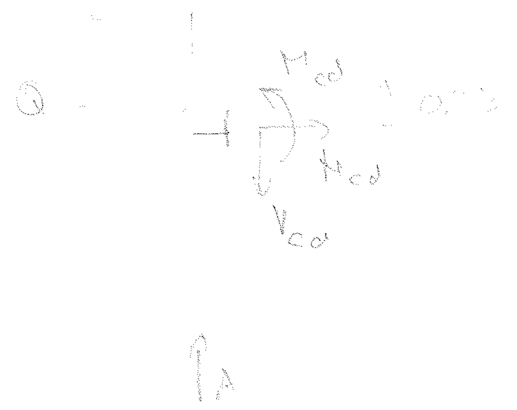
$Q_2 = 7{,}2 \cdot 2 = 14{,}4$

$Q_3 = \frac{4{,}8 \cdot 2}{2} = 4{,}8$

$H_{ce} = 0$

$V_{ce} = Q_2 + Q_3 = 14{,}4 + 4{,}8 = 19{,}2$

$M_{ce} = -Q_2 \cdot 1 - Q_3 \cdot 1{,}33 = -20{,}8$

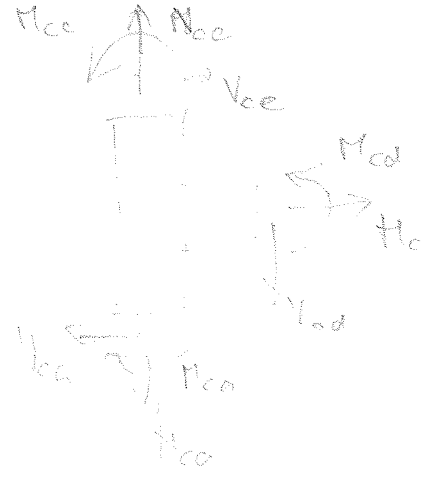


$V_{cd} = A = -15{,}714$

$H_{cd} = -Q = -30$

$M_{cd} = Q \cdot 0{,}333 = 10$

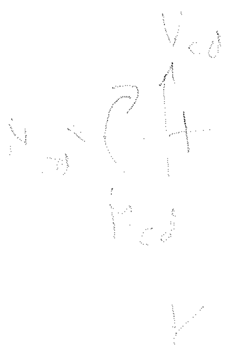
ALTERNATIVNĚ NEBO PRO KONTROLU



$H_{cd} = V_{ca} - V_{ce} = -10{,}8 - 19{,}2 = -30$

$V_{cd} = H_{ce} - H_{ca} = 0 - 15{,}714 = -15{,}714$

$M_{cd} = M_{ca} - M_{ce} = -10{,}8 - (-20{,}8) = 10$

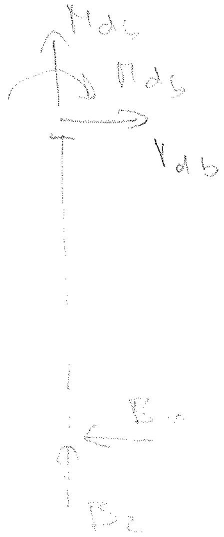


$M_{dc} = M_{cd} = -30$

$V_{dc} = V_{cd} = -15{,}714$

$M_{dc} = M_{cd} + V_{cd} \cdot 7$

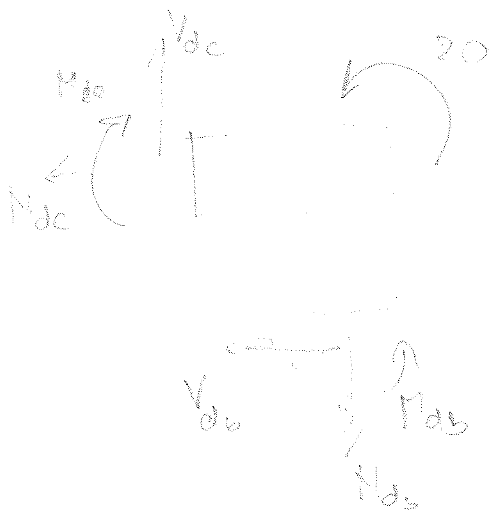
$= 10 - 15{,}714 \cdot 7 = -100$



$M_{db} = -B_z = -15{,}714$

$V_{db} = B_x = 30$

$M_{db} = -B_x \cdot 4 = -120$



$V_{dc} - N_{db} = -15{,}714$ [illegible]

$M_{dc} + V_{db} = -30 + 30$ [illegible]

$M_{db} + 20 - M_{dc} = -120 + 20 - (-100) = 0$