Dejan Zupan

IZPITNE NALOGE IN REŠITVE NALOG S POSTOPKOM IZ PREDMETA STATIKA NA UNIVERZITETNEM ŠTUDIJU GRADBENIŠTVA

Igor Planinc

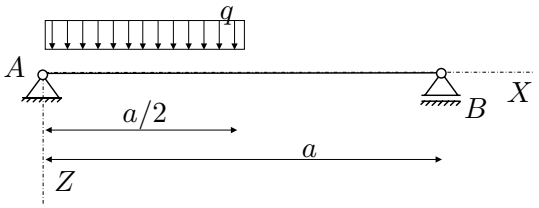
VPRAŠANJA IZ TEORIJE PRI PREDMETU STATIKA NA UNIVERZITETNEM ŠTUDIJU GRADBENIŠTVA

ŠTUDIJSKO LETO: 2004/05

STATIKA (UNI) - IZPITNI ROK (31. 01. 2005)

RAČUNSKI DEL IZPITA:

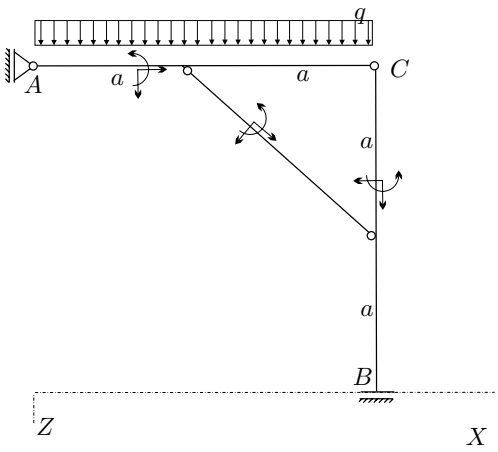
1. Za nosilec na sliki izračunajte in prikažite diagrame notranjih statičnih količin! (OBVEZNA NALOGA! 20%)



. . . . . .

2. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

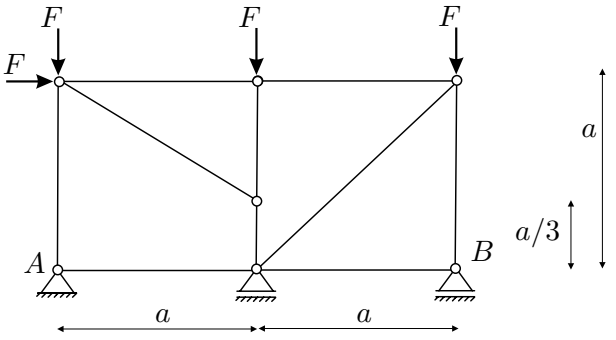
Podatki: $a = 4\,\mathrm{m}$, $q = 2\,\mathrm{kN/m}$
(OBVEZNA NALOGA! 45%)



. . . . . .

3. Za palično konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti in osne sile v vseh palicah! (35%)

Podatki: $a = 3\,\mathrm{m}$, $F = 5\,\mathrm{kN}$.



TEORETIČNI DEL IZPITA:

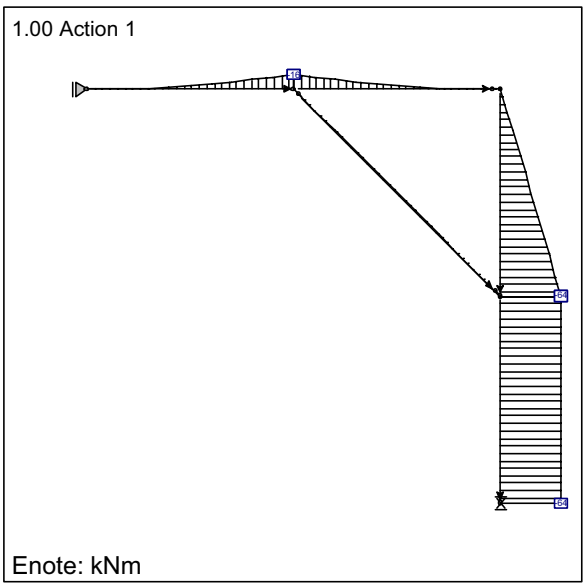
Izmed treh zastavljenih vprašanj si izberete dve, na kateri boste odgovarjali. Izbrani vprašanji jasno označite! Pišite čitljivo.

1. Ravnotežni par sil in dvojica sil!

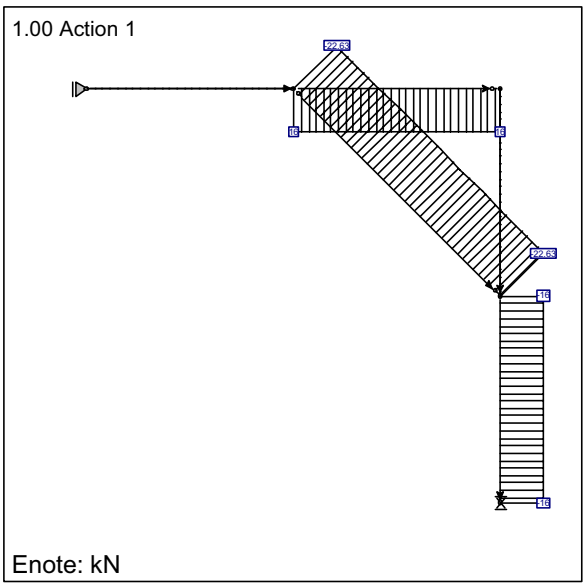
2. Pomiki in zasuki togega telesa (izpeljava enačb)!

3. Opišite določanje reakcij in notranjih sil statično določenih linijskih konstrukcij z izrekom o virtualnih pomikih (pomagajte si s primerom)!

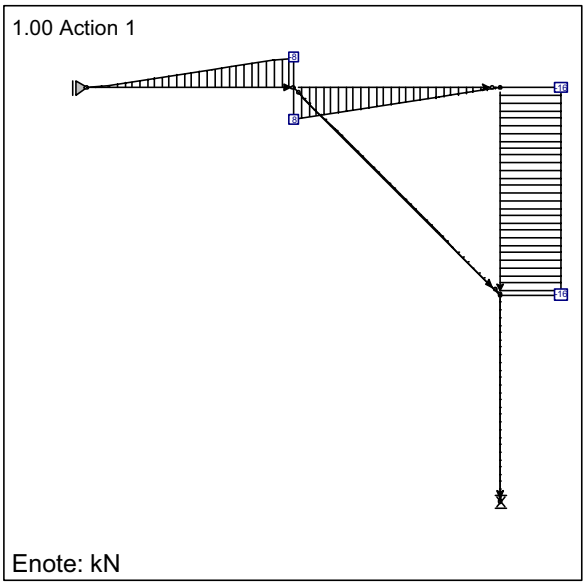
LC1: Load case 2: Upogibni moment My

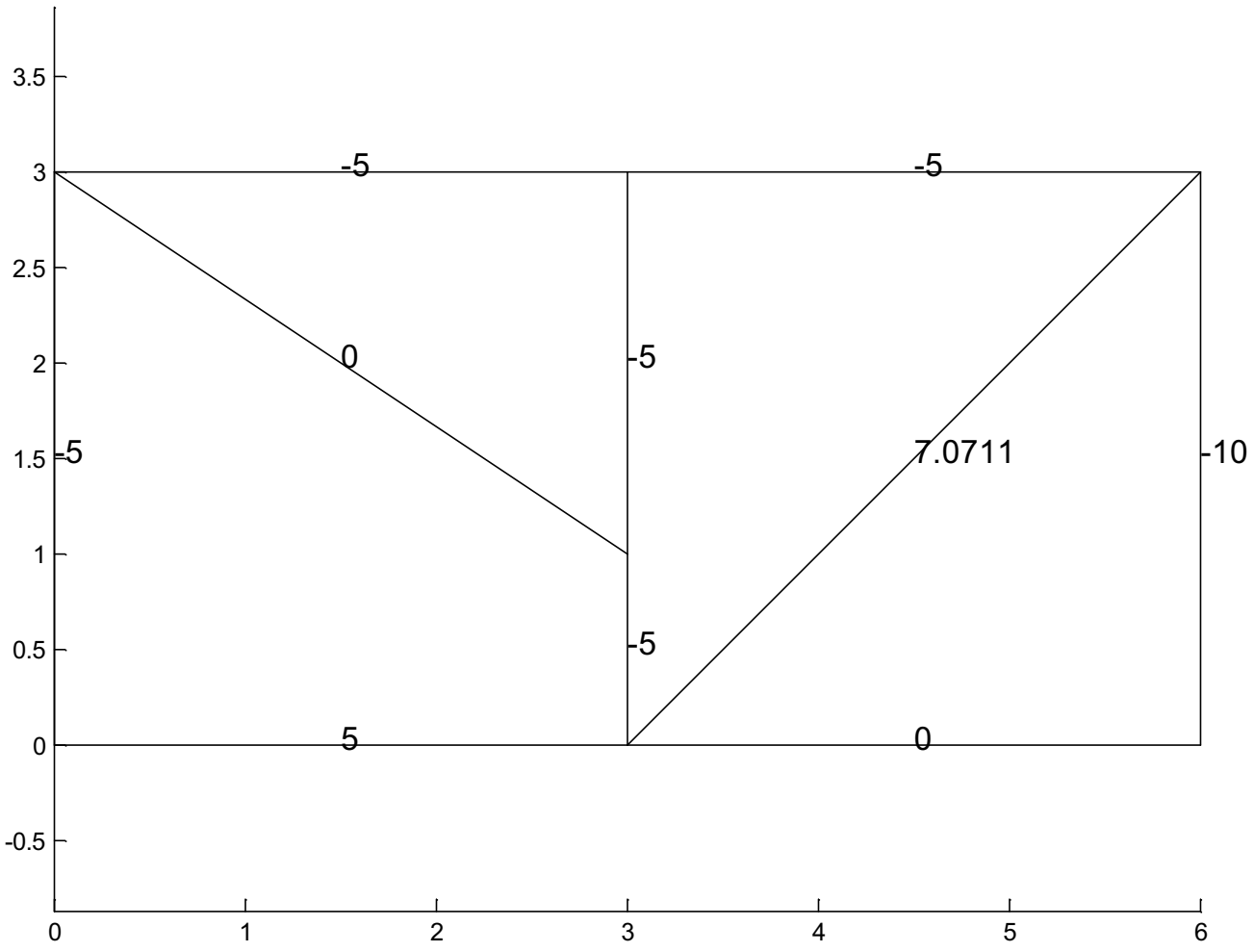


LC1: Load case 2: Osna sila Fx



LC1: Load case 2: Preèna sila Fz

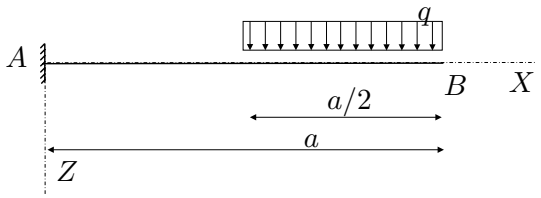



3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0
1
2
3
4
5
6
-5
-5
0
-5
-5
7.0711
-10
5
0

STATIKA (UNI) - 1. IZREDNI IZPITNI ROK (14. 3. 2005)

RAČUNSKI DEL IZPITA:

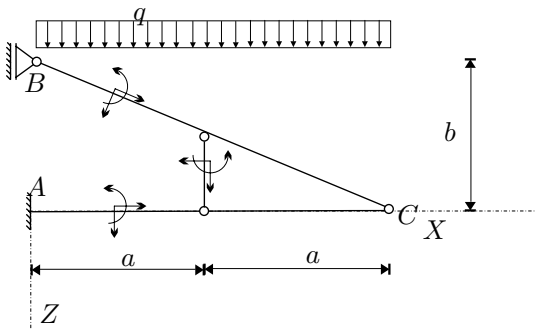
1. Za nosilec na sliki izračunajte reakcije v vezeh ter izračunajte in prikažite diagrame notranjih statičnih količin! (OBVEZNA NALOGA! 20%)



. . . . . .

2. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

Podatki: $a = 3\,\mathrm{m}$, $b = 2\,\mathrm{m}$,
$q = 10\,\mathrm{kN/m}$.
(OBVEZNA NALOGA! 50%)



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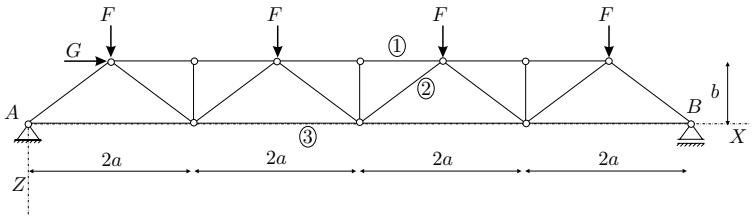
3. Za palično konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti in osne sile v palicah 1, 2 in 3! (30%)

Podatki: $a = 3\,\mathrm{m}$, $b = 2\,\mathrm{m}$,
$F = 5\,\mathrm{kN}$, $G = 10\,\mathrm{kN}$.



TEORETIČNI DEL IZPITA:

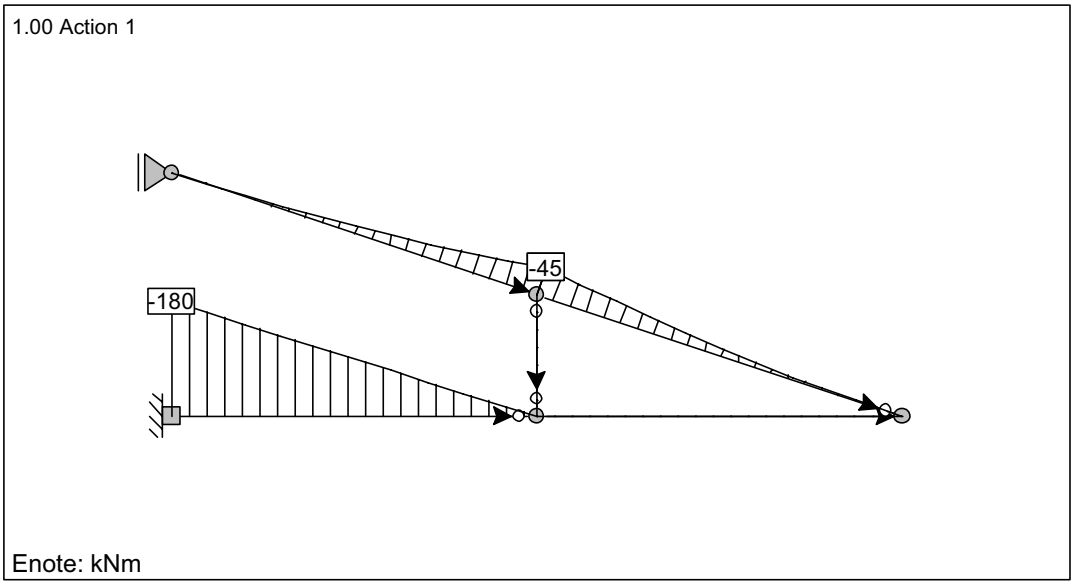
Izmed treh zastavljenih vprašanj si izberete dve, na kateri boste odgovarjali. Izbrani vprašanji jasno označite! Pišite čitljivo.

1. Izpeljite ravnotežne pogoje za sile, ki delujejo na sistemu delcev s togimi vezmi in togem telesu!

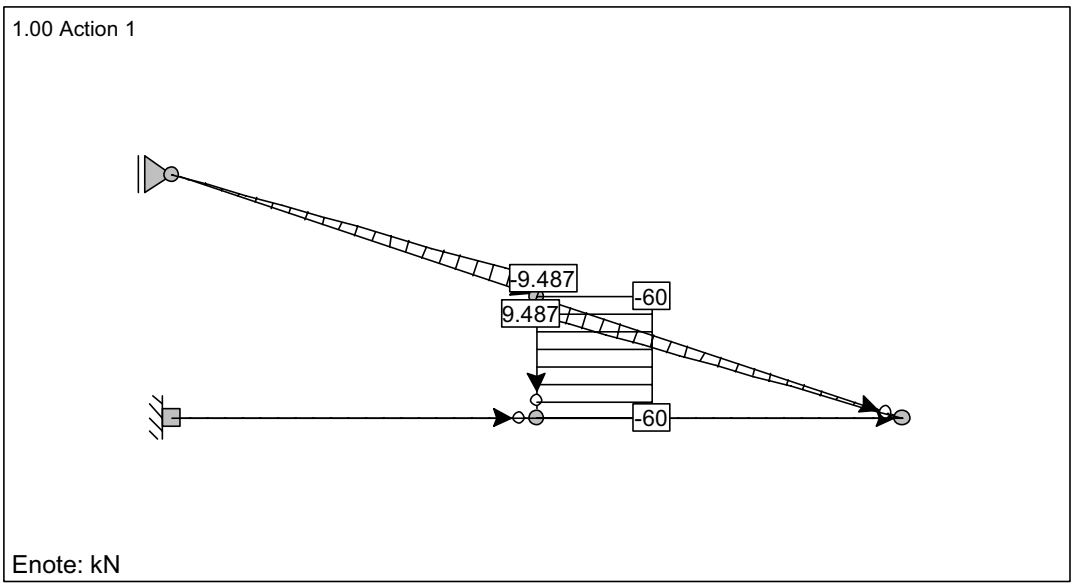
2. Opišite kinematične enačbe sistema togih teles ter postopek računanja dejanskega števila prostostnih stopenj sistema togih teles (ilustracija z značilnim primerom)!

3. Opišite določanje reakcij in notranjih sil statično določenih linijskih konstrukcij z izrekom o virtualnih pomikih (pomagajte si s primerom)!

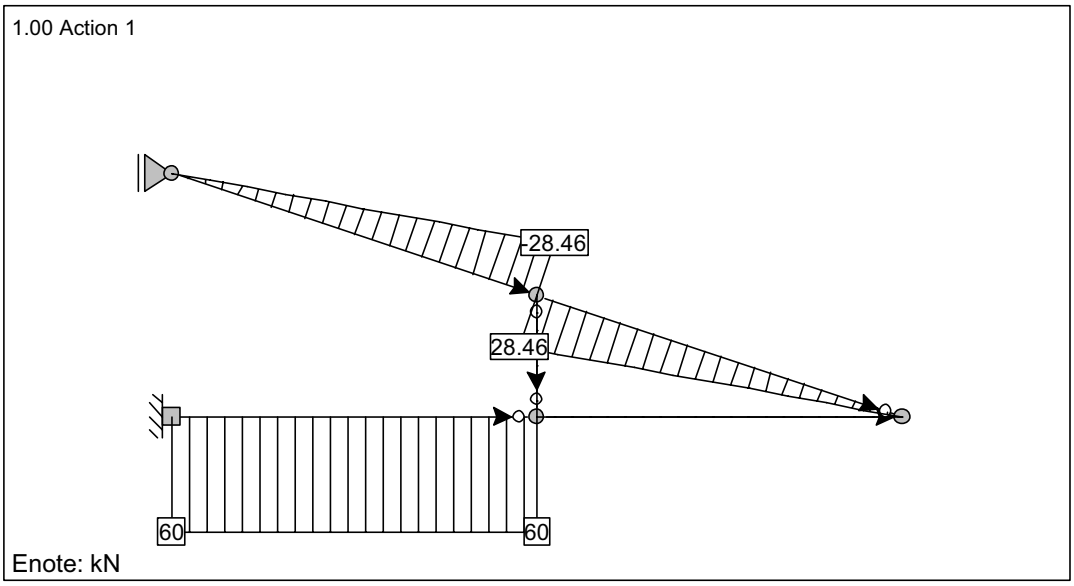
LC1: Load case 2: Upogibni moment My

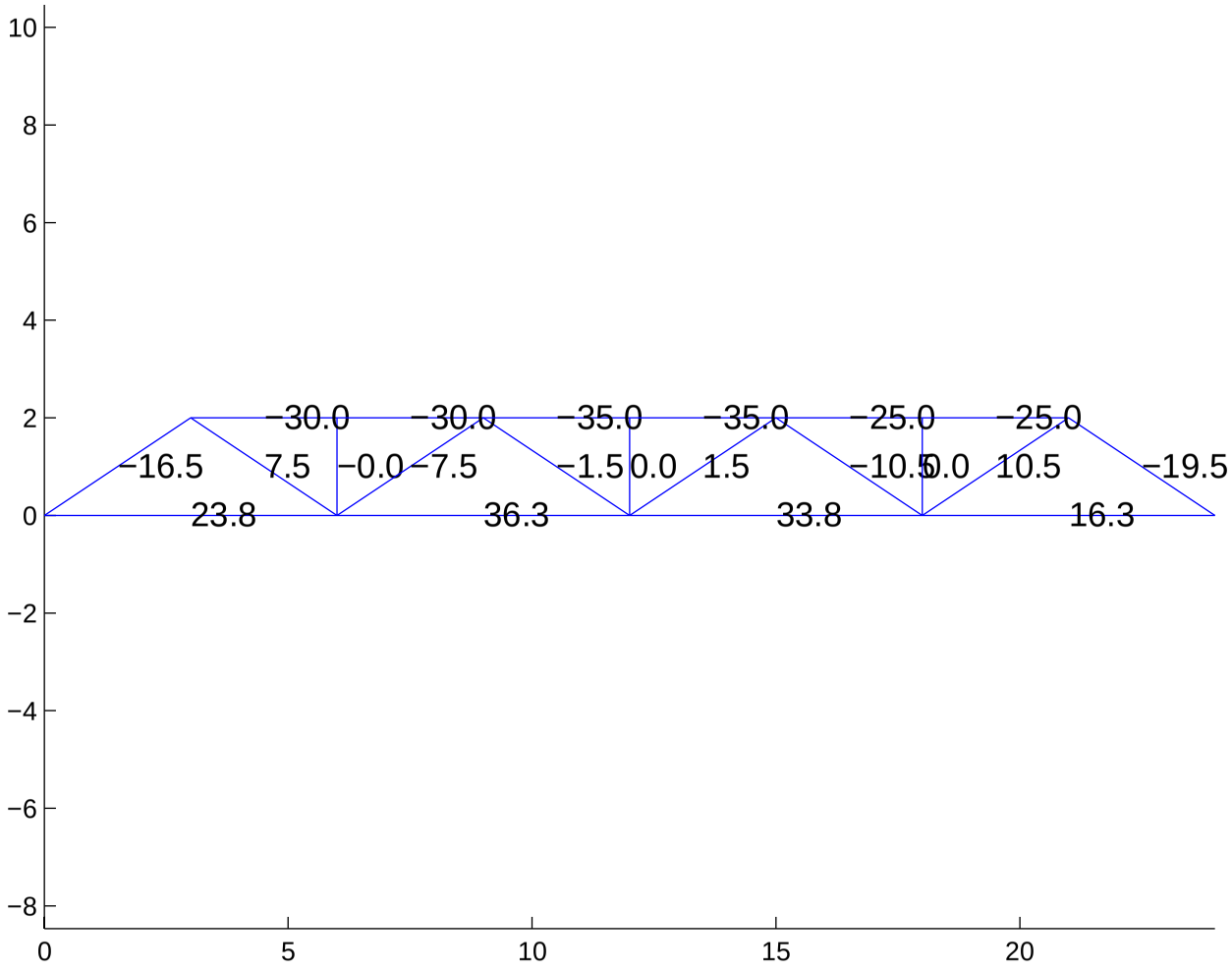


LC1: Load case 2: Osna sila Fx



LC1: Load case 2: Preèna sila Fz



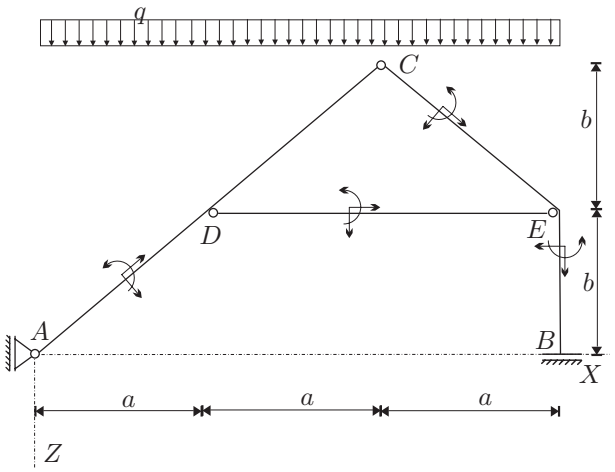

10
8
6
4
2
0
−2
−4
−6
−8
0
5
10
15
20
−30.0
−30.0
−35.0
−35.0
−25.0
−25.0
−16.5
7.5
−0.0
−7.5
−1.5
0.0
1.5
−10.5
0.0
10.5
−19.5
23.8
36.3
33.8
16.3

STATIKA (UNI) - 1. IZPITNI ROK (10. 6. 2005)

RAČUNSKI DEL IZPITA:

1. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

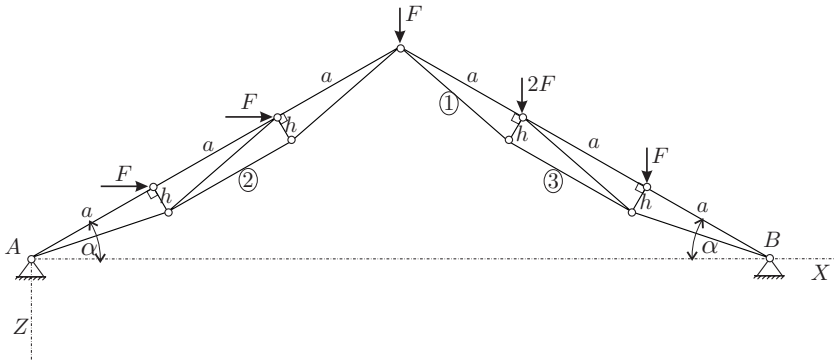
Podatki: $a = 4\,\mathrm{m}$, $b = 3\,\mathrm{m}$,
$q = 2\,\mathrm{kN/m}$.
(OBVEZNA NALOGA! 40%)



.....

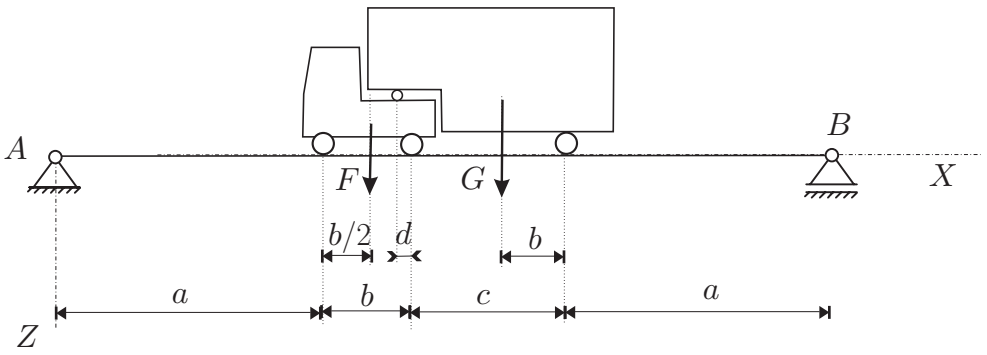
2. Za palično konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti in osne sile v palicah 1, 2 in 3! (30%)

Podatki: $a = 5\,\mathrm{m}$,
$h = 1\,\mathrm{m}$,
$\alpha = 30°$, $F = 5\,\mathrm{kN}$.



.....

3. Izračunajte in narišite diagram upogibnih momentov v mostu na sliki! Most (prostoležeči nosilec) je obremenjen le s težo vlačilca. Medosna razdalja vlačilca je b, razdalja od zadnje osi vlačilca do osi prikolice pa c. Prikolica je členkasto pripeta na vlačilec, vez leži za razdaljo d pred drugo osjo vlačilca. F je teža vlačilca, ki ima prijemališče na sredini, G pa teža prikolice, ki ima prijemališče na razdalji b pred osjo prikolice. (30%)
Podatki: $a = 15\,\mathrm{m}$, $b = 4\,\mathrm{m}$, $c = 10\,\mathrm{m}$, $d = 0.5\,\mathrm{m}$,
$F = 30\,\mathrm{kN}$, $G = 150\,\mathrm{kN}$.



STATIKA (UNI) - 1. IZPITNI ROK (10. 6. 2005)

TEORETIČNI DEL IZPITA:

Izmed treh zastavljenih vprašanj si izberete dve, na kateri boste odgovarjali. Izbrani vprašanji jasno označite! Pišite čitljivo.

1. Definicija števila prostostnih stopenj! Koliko prostostnih stopenj ima N masnih delcev, ki se gibljejo po krogli? Koliko prostostnih stopenj ima N togih teles, ki so povezana s členkom (odgovore utemeljite)?

2. Izpeljite ravnotežne pogoje za sistem delcev z breztežnimi togimi vezmi in togo telo!

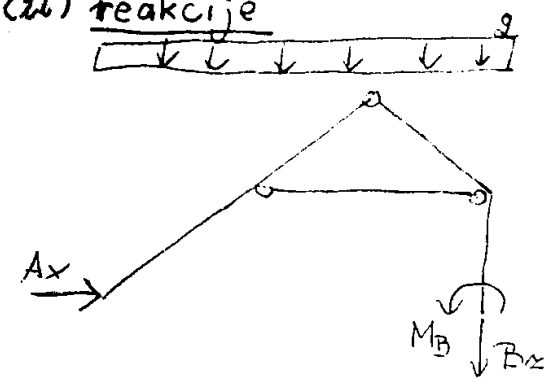
3. Opišite določanje reakcij in notranjih sil statično določenih linijskih konstrukcij z izrekom o virtualnih pomikih (pomagajte si s primerom)!

STATIKA – UNI 10. 6. 2005

1. NALOGA

(i) $n_{PB} = 3 \cdot 3 - 1 - 2 - 3 \cdot 2 = 0$

(ii) reakcije

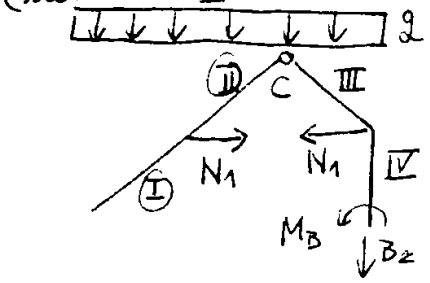


$\Sigma X: A_x = 0$ $\quad \boxed{A_x = 0}$

$\Sigma Z: B_z + q \cdot 3a = 0$ $\quad \boxed{B_z = -24\ kN}$

$\Sigma M^B: M_B + q \cdot 3a \cdot \frac{3a}{2} = 0$ $\quad \boxed{M_B = -144\ kNm}$

(iii) razrez



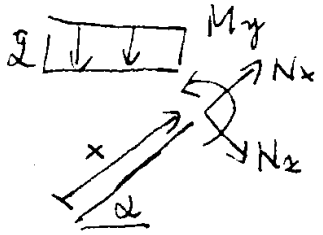
$\Sigma M^C_{AC}: \quad q \cdot 2a \cdot a + N_1 \cdot b = 0$

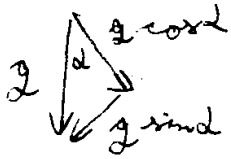
$N_1 = -\frac{q 2a^2}{b}$ $\quad \boxed{N_1 = -21{,}3\ kN}$

$N_1 = -\frac{64}{3}$

(iv) notranje sile

polje (I)





$\Sigma x: \quad N_x - q \sin\alpha \cdot x \cos\alpha = 0$

$\Sigma z: \quad N_z + q \cos\alpha \cdot x \cos\alpha = 0$

$\Sigma M^T \quad M_y + q x \cos\alpha \frac{x \cos\alpha}{2} = 0$

$x \in [0, \ell]$

$\operatorname{tg}\alpha = \frac{3}{4}$

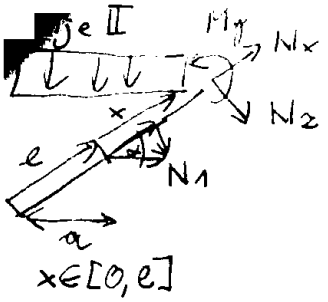
$\ell = \sqrt{4^2 + 3^2} = 5$

$\sin\alpha = \frac{3}{5}$

$\cos\alpha = \frac{4}{5}$

$N_x = \frac{24}{25} x$	$N_x(\ell) = 4{,}8$
$N_z = -\frac{32}{25} x$	$N_z(\ell) = -6{,}4$
$M_y = -\frac{16}{25} x^2$	$M_y(\ell) = -16$

polje II



$x \in [0, e]$

$\Sigma x: \; N_x - g \sin\alpha (a+x) \cos\alpha + N_1 \cdot \cos\alpha = 0$

$\Sigma z: \; N_z + g \cos\alpha (a+x) \cos\alpha + N_1 \cdot \sin\alpha = 0$

$\Sigma M^T: \; M_y + g(a+x)\cos\alpha \frac{(a+x)\cos\alpha}{2} + N_1 x \sin\alpha = 0$

$N_x = 4{\cdot}8 + \frac{64}{3}\cdot\frac{4}{5} + \frac{24}{5}x = 21{\cdot}9 + \frac{24}{25}x$

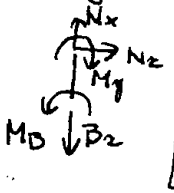
$N_z = -6{\cdot}4 + \frac{64}{3}\cdot\frac{3}{5} - \frac{32}{5}x = 6{\cdot}4 - \frac{32}{25}x$

$M_y = -16 + \frac{64}{3}\cdot\frac{3}{5}x - \frac{16}{25}x^2 - \frac{32}{25}x$

$= -16 + \frac{32}{5}x - \frac{16}{25}x^2$

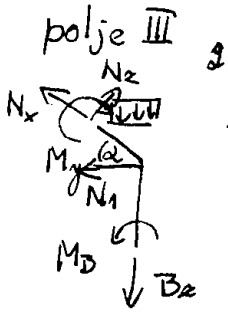
	$x=0$	$x=5$
N_x	21·9	26·7
N_z	6·4	0
M_y	−16	0

polje IV



$N_x = -24\,kN$
$M_y = -144\,kN$
$N_z = 0$

polje III



$\Sigma x: \; N_x - g\sin\alpha\,\bar{x}\cos\alpha - B_z \sin\alpha + N_1\cdot\cos\alpha = 0$

$\Sigma z: \; N_z - g\cos\alpha\,\bar{x}\cos\alpha - B_z\cos\alpha - N_1\sin\alpha = 0$

$\Sigma M^T: \; -M_y + M_D - B_z\bar{x}\cos\alpha - g\bar{x}\cos\alpha\frac{\bar{x}\cos\alpha}{2} + N_1\cdot\bar{x}\sin\alpha = 0$

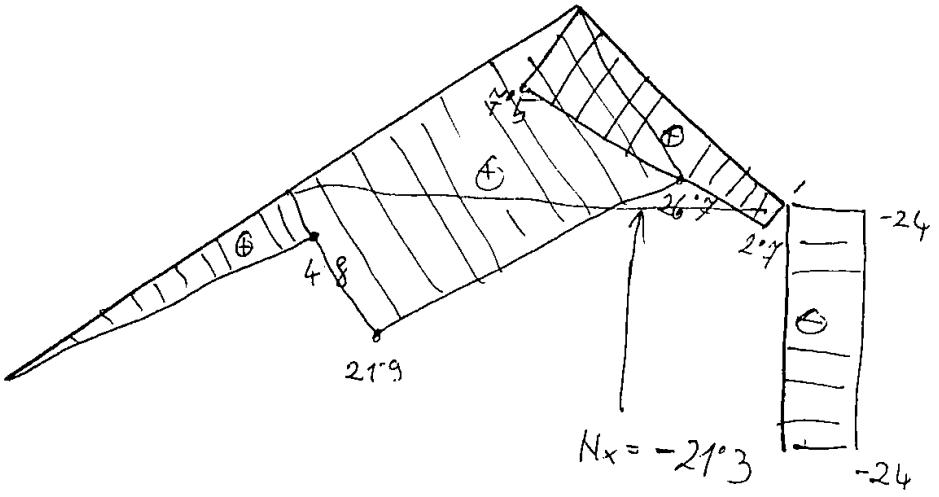
$N_x = -24\cdot\frac{3}{5} + \frac{24}{25}\bar{x} + \frac{64\cdot 4}{3\,5} = 2{\cdot}7 + \frac{24}{25}\bar{x}$

$N_z = -24\,\frac{4}{5} + \frac{32}{25}\bar{x} - \frac{64\cdot 3}{3\cdot 5} = -32 + \frac{32}{25}\bar{x}$

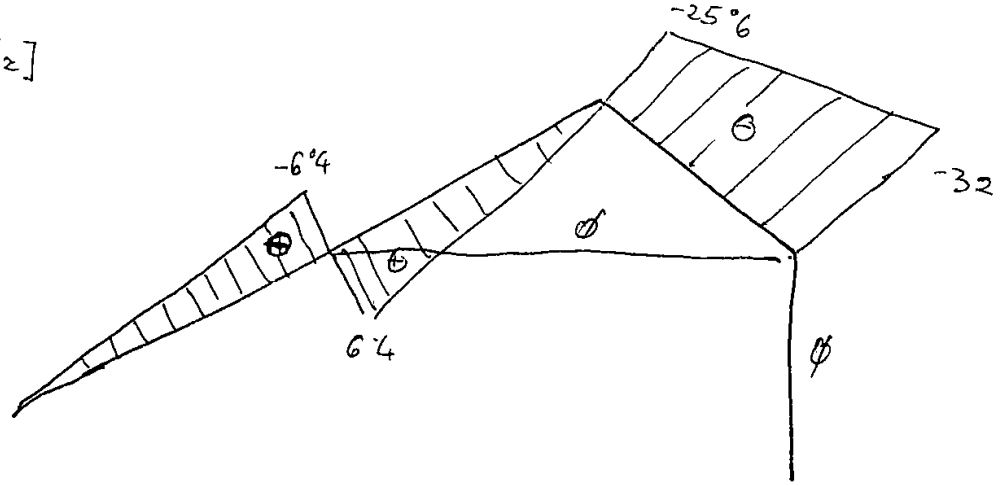
$M_y = -144 + 24\,\frac{4}{5}\bar{x} - \frac{16}{25}\bar{x}^2 + \frac{64}{5}\bar{x} = -144 + 32\bar{x} - \frac{16}{25}\bar{x}^2$

	$\bar{x}=0$	$x=\ell=5$
N_x	2·7	7·5
N_z	−32	−25·6
M_y	−144	0

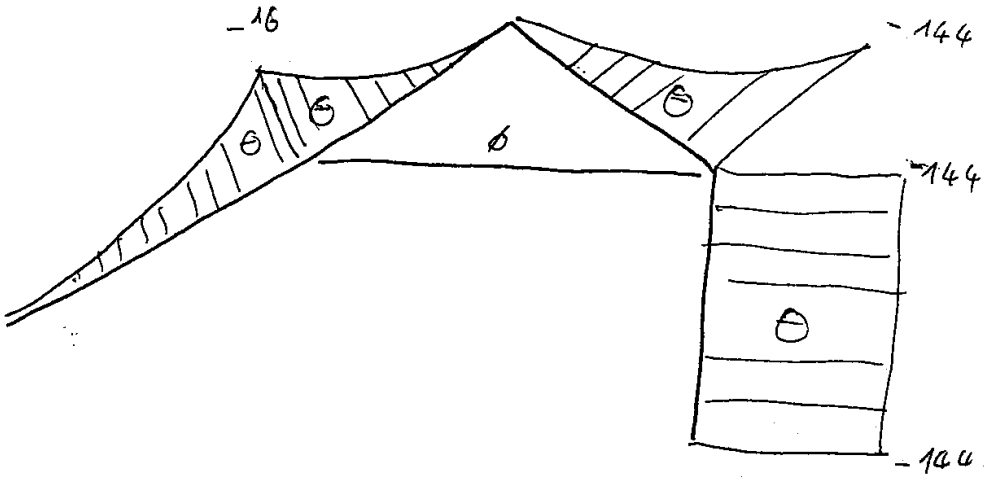
[N_x]



[N_z]



[M_y]

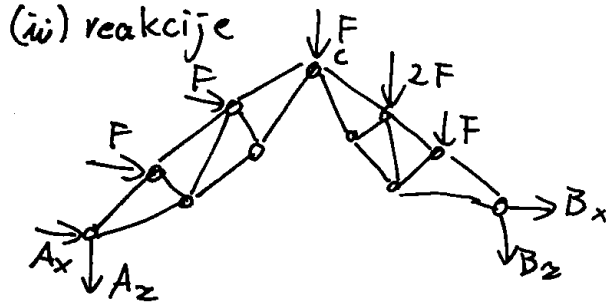


STATIKA - UNI 10.6.2005

2. NALOGA

(i) $\widetilde{m_{PS}} = 0$

(ii) reakcije



$\Sigma X: A_x + B_x = -2F$

$\Sigma Z: A_z + B_z = -4F$

$\Sigma M^A: B_z \cdot 6a \cos\alpha + F 3a \cos\alpha + 2F 4a \cos\alpha + F \cdot 5a \cos\alpha + F \cdot a \sin\alpha + F \cdot 2a \sin\alpha = 0$

$6 B_z \cos\alpha = -16 F \cdot \cos\alpha - 3F \cdot \sin\alpha$

$B_z = -\frac{8}{3}F - \frac{1}{2}F \cdot \operatorname{tg}\alpha$

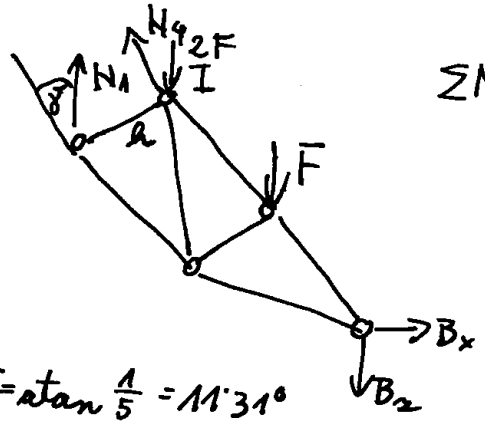
$\boxed{B_z = -14.8\ kN}$ $\boxed{A_z = -5.2\ kN}$

$\Sigma M^C: A_x \cdot 3a \cdot \sin\alpha + A_z \cdot 3a \cos\alpha + F \cdot 2a \sin\alpha + F \cdot a \sin\alpha = 0$

$A_x = -(A_z \operatorname{ctg}\alpha + F)$

$\boxed{A_x = 4.05\ kN}$ $\boxed{B_x = -14.05\ kN}$

(iii) palica ①



$\gamma = \operatorname{atan}\frac{1}{5} = 11.31°$

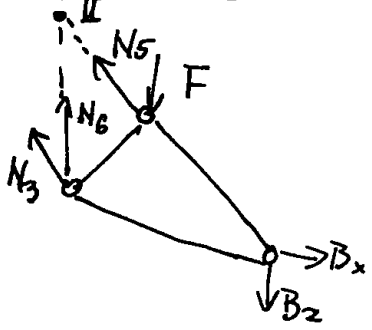
$-F \cdot a \cdot \cos\alpha$

$\Sigma M^I: B_x \cdot 2a \sin\alpha - B_z \cdot 2a \cos\alpha - N_1 \cdot \cos\gamma \cdot h = 0$

$N_1 = \frac{1 \cdot 2 \cdot 5}{\cos\gamma}\left(B_x \cdot \frac{1}{2} - B_z \cdot \frac{\sqrt{3}}{2} - F \cdot \frac{1}{2} \cdot \frac{\sqrt{3}}{2}\right)$

$\boxed{N_1 = 36.9\ kN}$

(zw) palica (3)

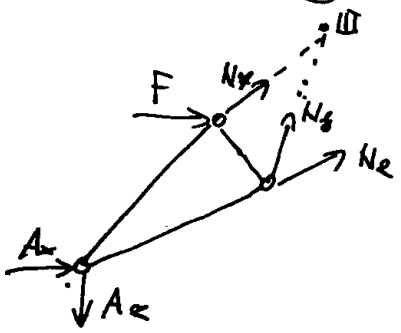


$$\Sigma M^{II}: \; B_x \cdot 2a \cdot \sin\alpha - B_z \cdot 2a \cdot \cos\alpha - F \cdot a \cdot \cos\alpha - N_3 \cdot h = 0$$

$$N_3 = 5 \cdot \left(B_x \cdot 2 \cdot \frac{1}{2} - B_z \cdot 2 \cdot \frac{\sqrt{3}}{2} - F \cdot \frac{\sqrt{3}}{2} \right)$$

$$\boxed{N_3 = 36.3 \text{ kN}}$$

(ar) palica (2)



$$\Sigma M^{III}: \; A_x \cdot 2a \cdot \sin\alpha + A_z \cdot 2a \cdot \cos\alpha + N_2 \cdot h + F \cdot a \cdot \sin\alpha = 0$$

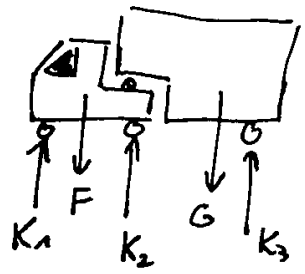
$$N_2 = -5 \left(A_x \cdot 2 \cdot \frac{1}{2} + A_z \cdot 2 \cdot \frac{\sqrt{3}}{2} + F \cdot \frac{1}{2} \right)$$

$$\boxed{N_2 = 12.3 \text{ kN}}$$

STATIKA - UNI 10.6.2005

3. NALOGA

a.) sile v kolesih



$\Sigma Z: \; K_1 + K_2 + K_3 = F + G$

$\Sigma M^{(1)}: \; -F \cdot \frac{b}{2} + K_2 \cdot b - G c + K_3 \cdot (b+c) = 0$

$\Sigma M^{vez} \; -G(c-b+d) + K_3(c+d) = 0$

$K_3 = G \frac{c+d-b}{c+d}$

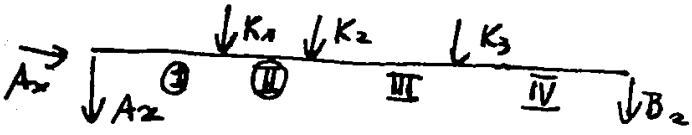
$K_3 = 150 \cdot \frac{6.5}{10.5} \Rightarrow \boxed{K_3 = 92.9 \text{ kN}}$

$K_2 = \frac{1}{b}\left(F \cdot \frac{b}{2} + G \cdot c - K_3 \cdot (b+c)\right)$

$\boxed{K_2 = 65 \text{ kN}}$

$\boxed{K_1 = 22.1 \text{ kN}}$

b.) Obtežba na mostu



$\Sigma x \; \boxed{A_x = 0}$

$\Sigma Z: \; A_z + B_z = -(K_1 + K_2 + K_3) = -180 \text{ kN}$

$\Sigma M^{A}: \; K_1 \cdot a + K_2 \cdot (a+b) + K_3 (a+b+c) + B_z \cdot (a+b+c+a) = 0$

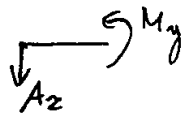
$B_z = -\frac{1}{44}(15K_1 + 19K_2 + 29K_3)$

$\boxed{B_z = -96.8 \text{ kN}}$

$\boxed{A_z = -83.2 \text{ kN}}$

c.) notranje sile :

polje Ⅰ

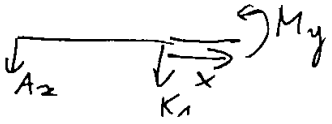


$M_y = -A_z x$

$\boxed{M_y = 832x}$

$M_y(15) = 1247{,}5$

polje Ⅱ

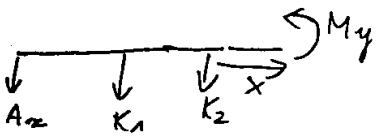


$M_y = 1247{,}5 - K_1 x - A_z x$

$\boxed{M_y = 1247{,}5 + 611x}$

$M_y(4) = 1491{,}9$

polje Ⅲ

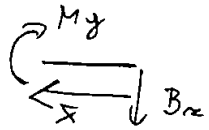


$M_y = 1491{,}9 - (A_z + K_1 + K_2)x$

$\boxed{M_y = 1491{,}9 - 3{,}9x}$

$M_y(10) = 1452{,}9$

polje Ⅳ

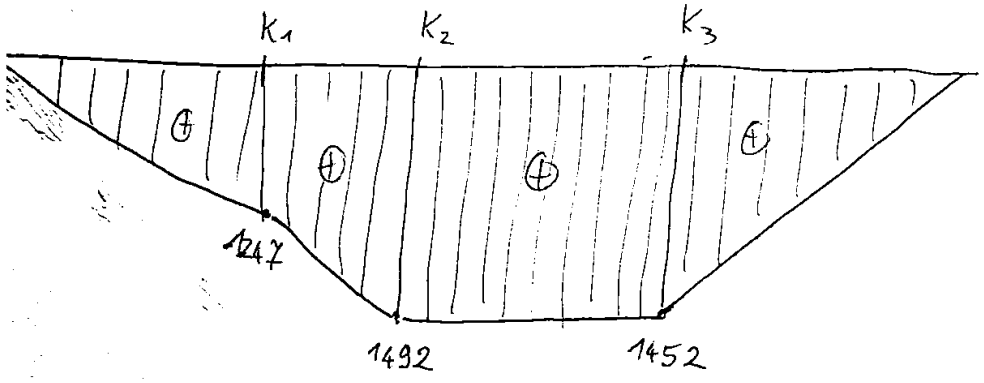


$M_y = -B_z \bar{x}$

$\boxed{M_y = 96{,}8\bar{x}}$

$M_y(15) = 1452\ kNm$

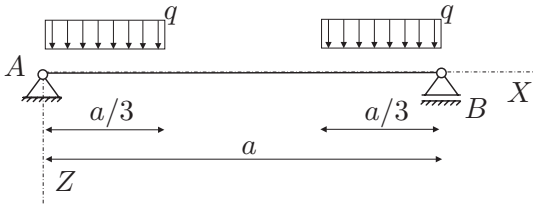
d.) diagrami



STATIKA (UNI) - 2. IZPITNI ROK (27. 6. 2005)

RAČUNSKI DEL IZPITA:

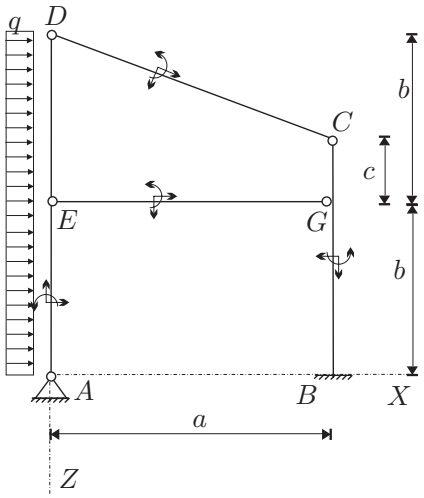
1. Za nosilec na sliki izračunajte reakcije v podporah ter izračunajte in prikažite diagrame notranjih statičnih količin! (OBVEZNA NALOGA! 20%)



.....

2. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

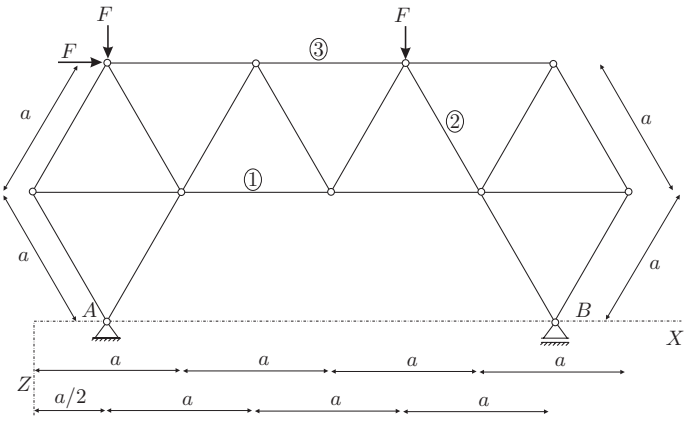
Podatki: $a = 4\,\mathrm{m}$, $b = 3\,\mathrm{m}$, $c = 1\,\mathrm{m}$, $q = 10\,\mathrm{kN/m}$.
(OBVEZNA NALOGA! 50%)



.....

3. Za palično konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti in osne sile v palicah 1, 2 in 3! (30%)

Podatki: $a = 2\mathrm{m}$, $F = 5\,\mathrm{kN}$.



TEORETIČNI DEL IZPITA:

Izmed treh zastavljenih vprašanj si izberete dve, na kateri boste odgovarjali. Izbrani vprašanji jasno označite! Pišite čitljivo.

1. Izpeljite in opišite nadomestne ravnotežne pogoje (razumevanje podkrepite s preprostim primerom)!

2. Zapišite izraz za računsko število prostostnih stopenj sistema togih teles (razumevanje podkrepite s preprostim primerom)!

3. Opišite določanje reakcij in notranjih sil statično določenih linijskih konstrukcij z izrekom o virtualnih pomikih (pomagajte si s primerom)!

STATIKA – UNI 27. 6. 2005

1. NALOGA

a) reakcije

$\Sigma X: \quad \boxed{A_x = 0}$

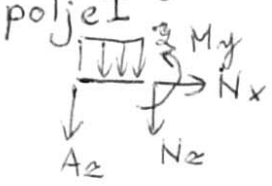
$\Sigma Z: \quad A_z + B_z = -\frac{q2a}{3}$

$\Sigma M^A: \quad -B_z a - q\frac{a}{3}\cdot\frac{a}{6} - q\frac{a}{3}\cdot\frac{5a}{6} = 0$

$\boxed{B_z = -\frac{qa}{3}} \quad \boxed{A_z = -\frac{qa}{3}}$

b) notranje sile

polje I



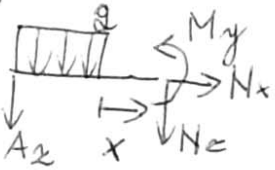
$\boxed{N_x = 0}$

$N_z = -A_z - qx \Rightarrow \boxed{N_z = \frac{qa}{3} - qx} \quad N_z(0) = \frac{qa}{3} \quad N_z(\frac{a}{3}) = 0$

$M_y = -A_z x - qx\frac{x}{2} \Rightarrow \boxed{M_y = \frac{qa}{3}x - q\frac{x^2}{2}} \quad M_y(0) = 0$

$M_y(\frac{a}{3}) = \frac{qa^2}{18}$

polje II



$\boxed{N_x = 0}$

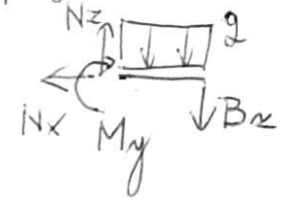
$N_z = -A_z - q\frac{a}{3} \quad \boxed{N_z = 0}$

$M_y = -A_z(\frac{a}{3} + x) - q\frac{a}{3}\cdot(\frac{a}{3} + x)$

$= \frac{qa^2}{18}$

$\boxed{M_y = \frac{qa^2}{18}}$

polje III



$\boxed{N_x = 0}$

$N_z = B_z + q\bar{x} \quad \boxed{N_z = -\frac{qa}{3} + q\bar{x}}$

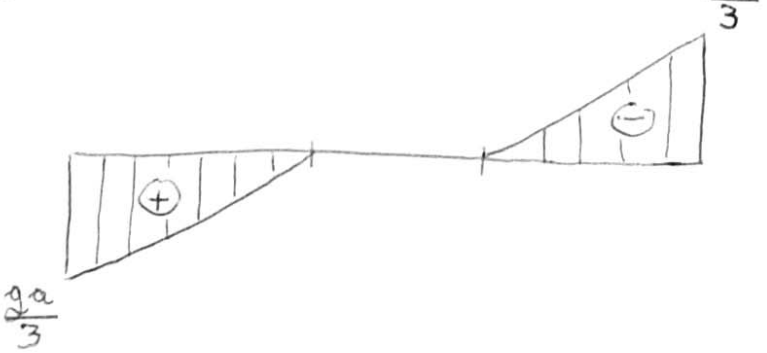
$M_y = -B_z\bar{x} - q\bar{x}\frac{\bar{x}}{2} \quad \boxed{M_y = \frac{qa}{3}\bar{x} - q\frac{\bar{x}^2}{2}} \quad M_y(0) = 0$

$M_y(\frac{a}{3}) = \frac{qa^2}{18}$

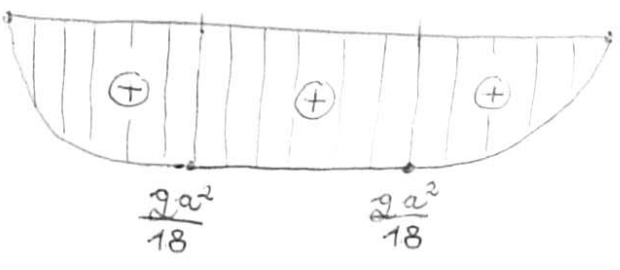
c) diagrami

[N_z]

[N_z]



[M_y]

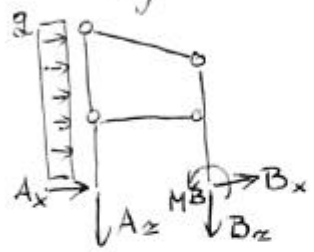


STATIKA - UNI 27. 6. 2005

2. NALOGA

a.) $\tilde{n}_{PS} = 5 \cdot 3 - 2 - 3 - 3 \cdot 2 - 4 = 0$

b.) reakcije



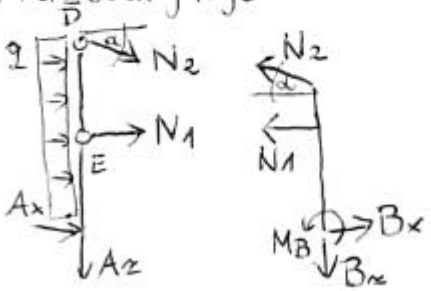
$\Sigma X: \; A_x + B_x = -q 2b$ $\quad \boxed{B_x = -45\ kN}$

$\Sigma Z: \; A_z + B_z = 0$

$\Sigma M^A: \; M_B - B_z \cdot a - q \cdot 2b \cdot b = 0$

$\Sigma M^E_{AE}: \; A_x \cdot b + q \cdot b \cdot \frac{b}{2} = 0$ $\quad \boxed{A_x = -q\frac{b}{2} = -15\ kN}$

c.) razstavljanje



ΣX desni del: $-N_1 - N_2 \cos\alpha + B_x = 0$

ΣZ desni del: $-N_2 \sin\alpha + B_z = 0$

ΣM^B desni del: $M_B + N_1 \cdot b + N_2(b+c)\cdot\cos\alpha = 0$

ΣM^E_{DE} levi del: $-N_2 \cos\alpha \cdot b - q\,b\,\frac{b}{2} = 0$

$\boxed{N_2 = -\frac{qb}{2\cos\alpha}}$ $\quad tg\alpha = \frac{2}{4} \Rightarrow \alpha = 26{,}565°$

$\boxed{N_2 = -16{,}8\ kN}$

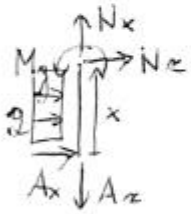
$\boxed{N_1 = -30\ kN}$

$\boxed{B_z = -7{,}5\ kN}$ $\quad \boxed{M_B = 150\ kNm}$ $\quad \boxed{A_z = 7{,}5\ kN}$

KONTROLA: $\Sigma M^A: \; 150 + 7{,}5 \cdot 4 - 10 \cdot 6 \cdot 3 = 0$ ✓

d) notranje sile

polje (I)



$\boxed{N_x = A_z = 7{,}5\ kN}$

$N_z = -A_x - qx$

$\boxed{N_z = 15 - 10x}$

$M_y = -A_x x - q x \frac{x}{2}$

$\boxed{M_y = 15x - 5x^2}$

$M_y(0) = M_y(3) = 0$

$M_y(\frac{3}{2}) = 11{,}25\ kNm$ (ekstrem)

polje (II)

$\boxed{N_x = -N_2 \cdot \sin\alpha = 7{,}5\ kN}$

$N_z = N_2 \cos\alpha + q\bar{x}$

$\boxed{N_z = -15 + 10\bar{x}}$

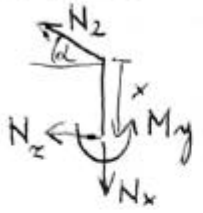
$M_y = -N_2 \cos\alpha\,\bar{x} - q\bar{x}\frac{\bar{x}}{2}$

$\boxed{M_y = 15\bar{x} - 5\bar{x}^2}$

$M_y(0) = M_y(3) = 0$

$M_y(\frac{3}{2}) = 11{,}25\ kNm$ (ekstrem)

polje III

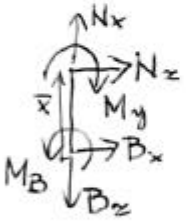


$N_x = N_2 \sin\alpha$ $\boxed{N_x = -7{,}5\ kN}$

$N_z = -N_2 \cos\alpha$ $\boxed{N_z = 15\ kN}$

$M_y = -N_2 \cos\alpha \cdot x$ $\boxed{M_y = 15x}$ $M_y(0) = 0$ $M_y(1) = 15\ kNm$

polje IV



$N_x = B_z$

$N_z = -B_x$

$M_y = B_x \bar{x} + M_B$

$\boxed{N_x = -7{,}5\ kN}$

$\boxed{N_z = 45\ kN}$

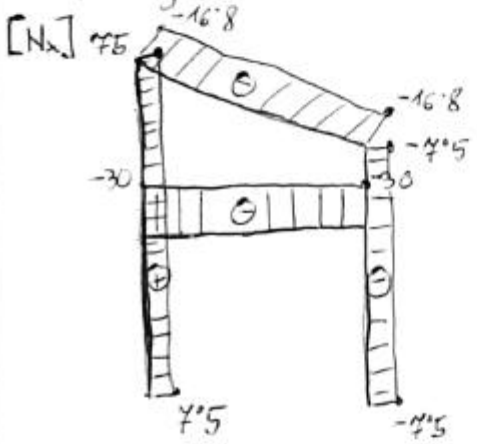
$\boxed{M_y = 150 - 45\bar{x}}$

$M_y(0) = 150\ kNm$ ✓

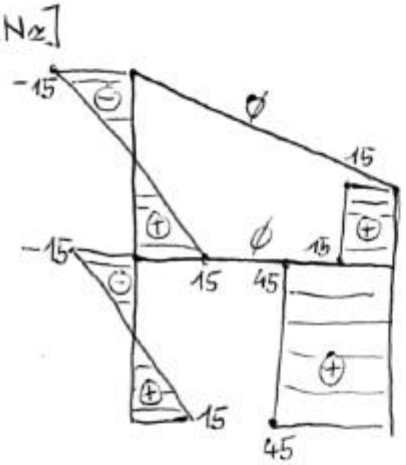
$M_y(3) = 15\ kNm$ ✓

e) diagrami

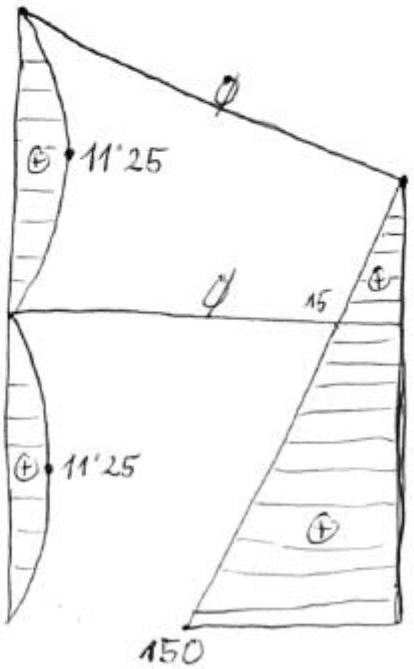
[Nx]



[Nz]

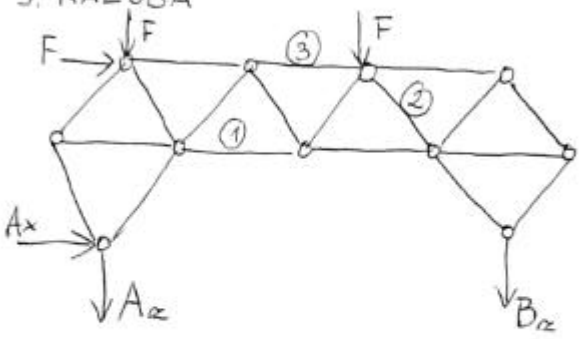


[My]



STATIKA -UNI 27.6.2005

3. NALOGA



reakcije

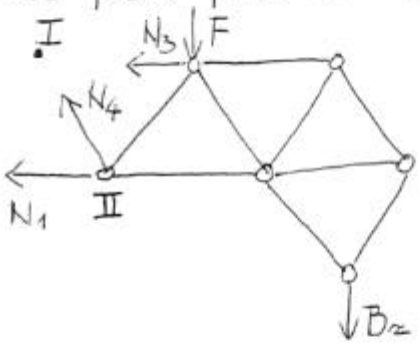
$\Sigma X: A_x + F = 0$ $\quad \boxed{A_x = -5\,kN}$

$\Sigma Z: A_z + B_z + 2F = 0$

$\Sigma M^A: -B_z \cdot 3a - F \cdot 2a - F \cdot 2a \frac{\sqrt{3}}{2} = 0$

$\boxed{B_z = -6.22\,kN}$ $\quad \boxed{A_z = -3.78\,kN}$

rez preko palic ① in ③



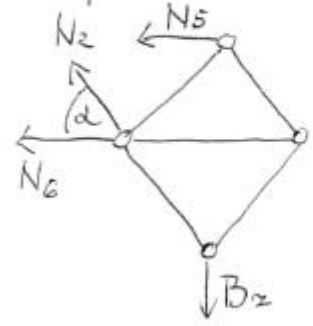
$\Sigma M^I: -Fa - B_z \cdot 2a - N_1 \cdot a \cdot \frac{\sqrt{3}}{2} = 0$

$N_1 = \frac{2}{\sqrt{3}}(-F - 2B_z)$ $\quad \boxed{N_1 = 8.6\,kN}$

$\Sigma M^{II}: -F\frac{a}{2} - B_z \frac{3a}{2} + N_3 \cdot a \frac{\sqrt{3}}{2} = 0$

$N_3 = \frac{1}{\sqrt{3}}(F + 3B_z)$ $\quad \boxed{N_3 = -7.9\,kN}$

rez palice ②



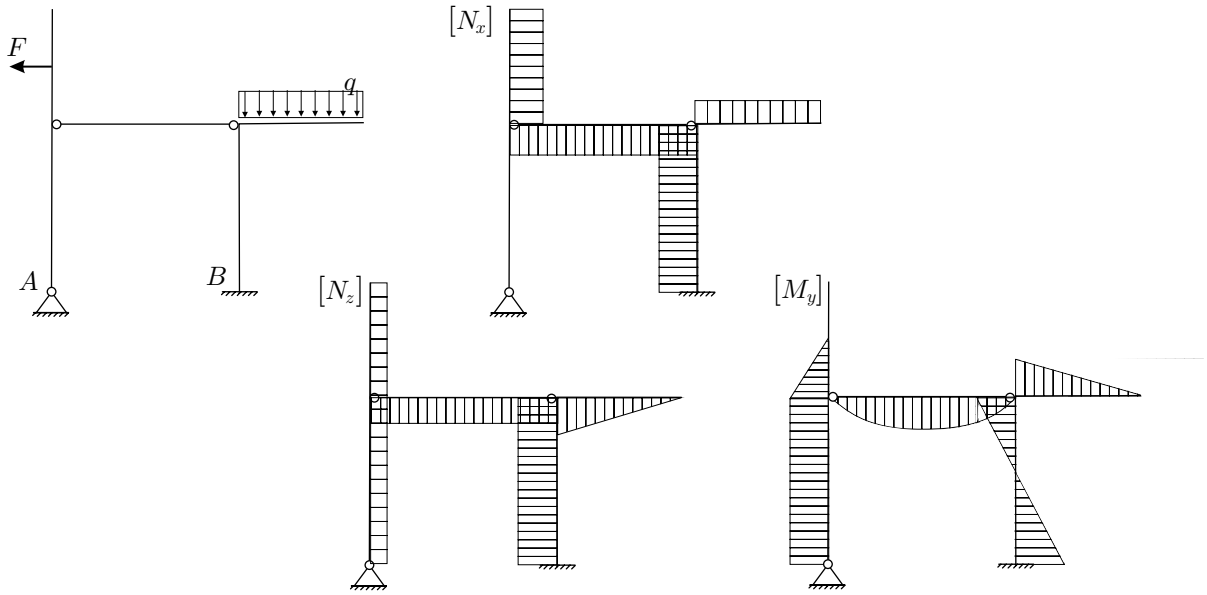
$\Sigma Z: -N_2 \sin\alpha + B_z = 0$

$N_2 = \frac{B_z}{\sin 60°}$ $\quad \boxed{N_2 = -7.2\,kN}$

STATIKA (UNI) - 3. IZPITNI ROK (1. 9. 2005)

RAČUNSKI DEL IZPITA:

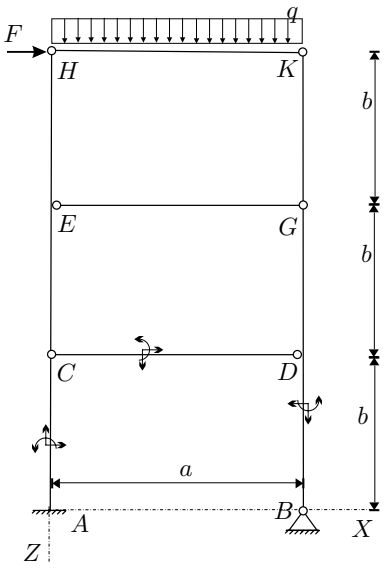
1. Janezek je na izpitu iz statike padel. Njegovi diagrami so polni napak. Pomagaj Janezku in poišči (BREZ RAČUNANJA) vse napake v spodnjih diagramih ! (OBVEZNA NALOGA! 25%)



.....

2. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

Podatki: $a = 4\,\mathrm{m}$, $b = 3\,\mathrm{m}$,
$q = 15\,\mathrm{kN/m}$, $F = 10\,\mathrm{kN}$.
(OBVEZNA NALOGA! 50%)



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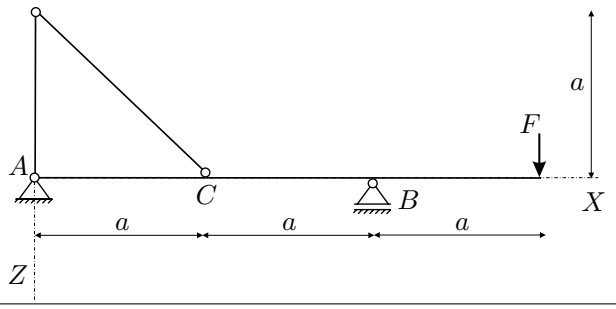
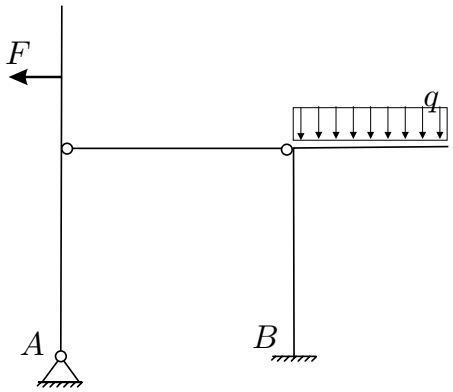
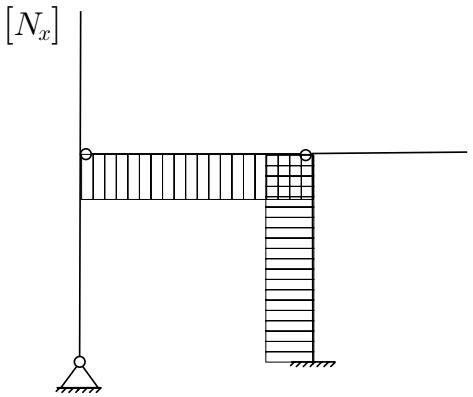
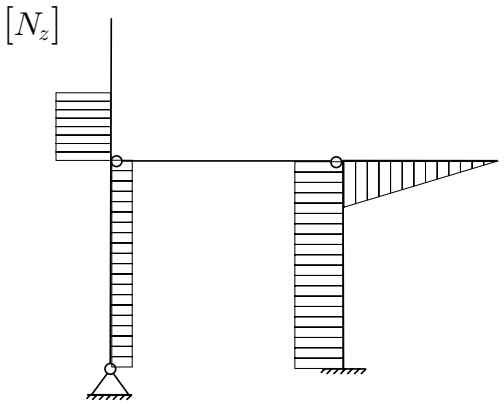
3. S principom virtualnega dela za konstrukcijo na sliki izračunajte reakcije v podporah in notranji moment v točki C – M_C! (25%)

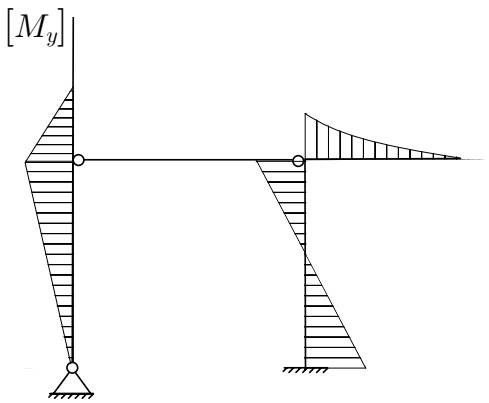


1. Naloga: PRAVILNI DIAGRAMI









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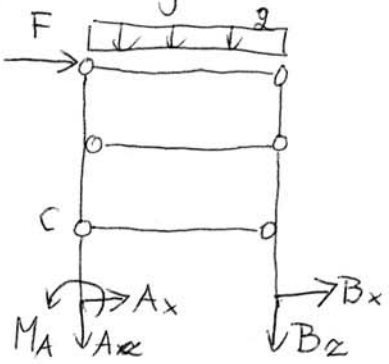
2. NALOGA

a.) $\tilde{m}_{PS} = 7 \cdot 3 - 3 - 2 - 4 \cdot 2 - 2 \cdot 2 \cdot (3-1) = 0$

b.) reakcije



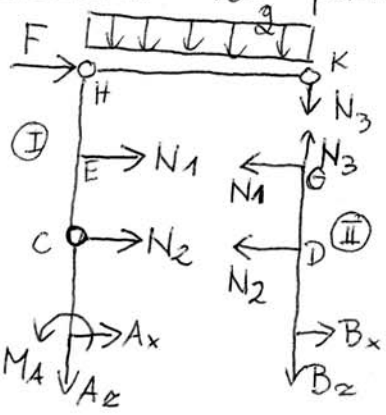
$\Sigma X: \quad A_x + B_x + F = 0$

$\Sigma Z: \quad A_z + B_z + q \cdot a = 0$

$\Sigma M^A: \quad M_A - B_z \cdot a - F \cdot 3b - q a \frac{a}{2} = 0$

$\underset{AC}{\Sigma M^C}: \quad M_A + A_x \cdot b = 0$

Izrežemo vse palice



$\underset{HK}{\Sigma M^H}: \quad -N_3 a - q \cdot a \cdot \frac{a}{2} = 0$

$N_3 = -q\frac{a}{2}$ | $N_3 = -30$ kN

$\Sigma Z^{II}: \quad -N_3 + B_z = 0$

$B_z = -30$ kN | $A_z = -30$ kN

$M_A = 90$ kNm

$A_x = -30$ kN | $B_x = 20$ kN

$\Sigma X^{III}: \quad -N_1 - N_2 + B_x = 0$

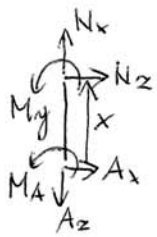
$\cdot \Sigma M^{B\,III}: \quad N_1 \cdot 2b + N_2 \cdot b = 0$

$N_1 = -\frac{N_2}{2}$ $\qquad -\frac{N_2}{2} = -B_x$

$N_2 = 40$ kN | $N_1 = -20$ kN

c.) notranje sile

I polje AC



$N_x = A_z$

$N_z = -A_x$

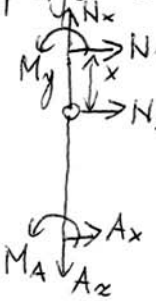
$M_y = -M_A - A_x \cdot x$

$N_x = -30$ kN

$N_z = 30$ kN

$M_y = -90 + 30x$

II polje CE



$N_x = A_z$

$N_z = -A_x - N_2$

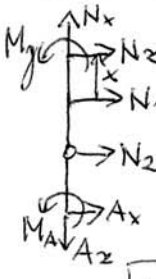
$M_y = -M_A - A_x(b+x) - N_2 x$

$N_x = -30$ kN

$N_z = -10$ kN

$M_y = -10x$

III polje EH



$N_x = A_z$

$N_z = -A_x - N_1 - N_2$

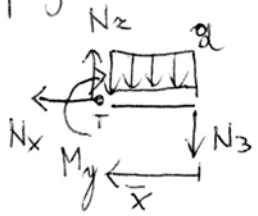
$M_y = -M_A - A_x(2b+x) - N_1 x - N_2(b+x)$

$N_x = -30$ kN

$N_z = 10$ kN

$M_y = -30 + 10x$

(IV) polje HK



Σx $\boxed{N_x = 0}$

Σz: $-N_z + N_3 + g\bar{x} = 0$

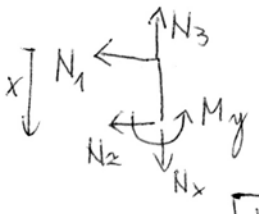
ΣM^T: $-M_y - N_3 \cdot \bar{x} - g\bar{x}\frac{\bar{x}}{2} = 0$

$\boxed{N_z = -30 + 15\bar{x}}$

$\boxed{M_y = 30x - 7{,}5\,x^2}$

$M_y(2) = 30$ kNm [extrem]

(V) polje GD



$N_x = N_3$

$N_z = -N_1$

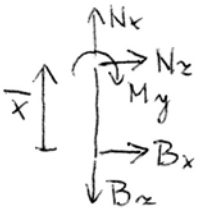
$M_y = -N_1 x$

$\boxed{N_x = -30\text{ kN}}$

$\boxed{N_z = 20\text{ kN}}$

$\boxed{M_y = 20x}$

(VI) polje BD



$N_x = B_z$

$N_z = -B_x$

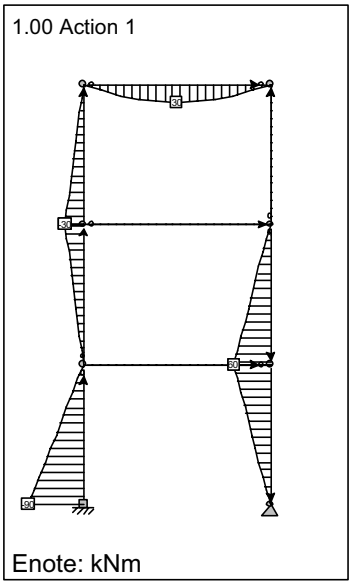
$M_y = B_x \cdot \bar{x}$

$\boxed{N_x = -30\text{ kN}}$

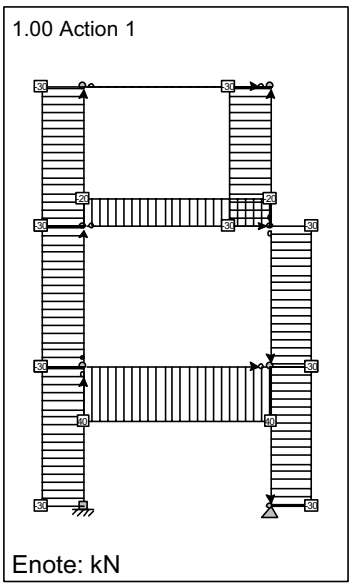
$\boxed{N_z = -20\text{ kN}}$

$\boxed{M_y = 20\bar{x}}$

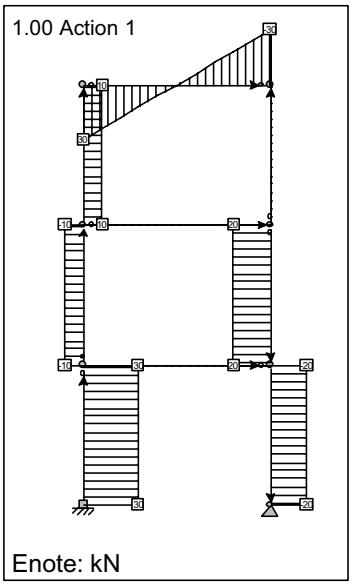
LC1: Load case 2: Upogibni moment My



LC1: Load case 2: Osna sila Fx



LC1: Load case 2: Preèna sila Fz



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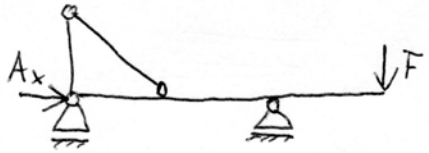
3. NALOGA

a.) Reakcija A_x



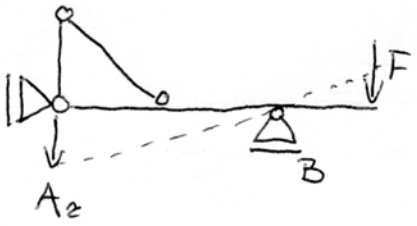
$$\delta W = A_x \delta u_A + F \delta w_F = 0$$

$$\delta w_F = 0$$

$$A_x \delta u_A = 0$$

$$\boxed{A_x = 0}$$

b.) Reakcija A_z



$$\delta W = A_z \delta w_A + F \delta w_F = 0$$

$$\delta u_F = \delta u_A = 0$$

$$\delta w_F = \delta w_A - 3a \delta \varphi_A$$

$$\delta w_B = \delta w_A - 2a \delta \varphi_A \Rightarrow \delta w_A = 2a \delta \varphi_A$$

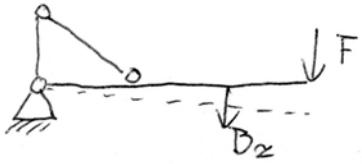
($\delta w_B = 0$)

$$\boxed{\delta w_F = -\frac{1}{2} \delta w_A}$$

$$\delta W = A_z \delta w_A - \frac{F}{2} \delta w_A = 0$$

$$\boxed{A_z = \frac{F}{2}}$$

c.) Reakcija B_z



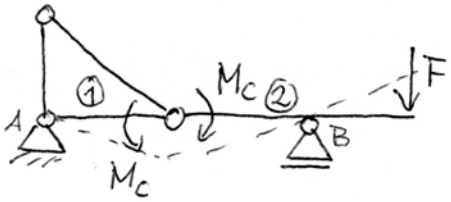
$$\delta W = B_z \delta w_B + F \delta w_F = 0$$

$$\left.\begin{aligned} \delta w_B &= \delta w_A - 2a \delta \varphi_A \\ \delta w_F &= \delta w_A - 3a \delta \varphi_A \end{aligned}\right\} \delta w_F = \frac{3}{2} \delta w_B$$

($\delta w_A = 0$)

$$B_z \delta w_B + \frac{3}{2} F \delta w_B = 0 \Rightarrow \boxed{B_z = -\frac{3}{2} F}$$

d.) Notranji moment M_c



$$\delta W = M_c \delta \varphi_c^{(1)} - M_c \delta \varphi_c^{(2)} + F \delta w_F = 0$$

$$\delta \varphi_c^{(1)} = \delta \varphi_A$$

$$\delta u_C = \delta u_A = 0$$

$$\delta w_C = \delta w_A - a \delta \varphi_A$$

($\delta w_A = 0$)

$$\delta w_F = \delta w_B - a \delta \varphi_B$$

($\delta w_B = 0$)

$$\delta \varphi_B = \delta \varphi_c^{(2)}$$

$$\delta u_B = \delta u_C = 0$$

$$\delta w_B = \delta w_C - a \delta \varphi_c^{(2)}$$

($\delta w_B = 0$)

$$\boxed{\delta \varphi_c^{(2)} = -\delta \varphi_c^{(1)}}$$

$$\boxed{\delta w_F = -a \delta \varphi_c^{(2)}}$$

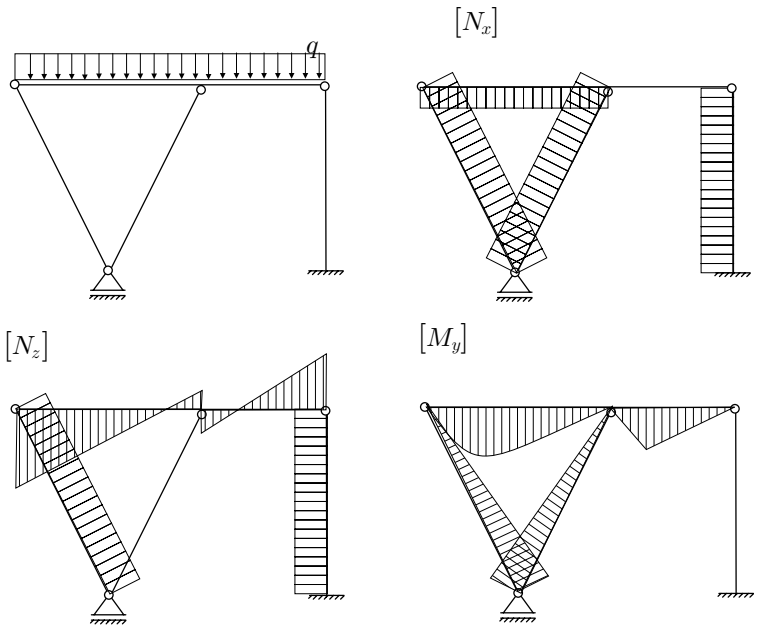
$$M_c \delta \varphi_c^{(1)} + M_c \delta \varphi_c^{(1)} + aF \delta \varphi_c^{(1)} = 0$$

$$\boxed{M_c = -\frac{aF}{2}}$$

STATIKA (UNI) - 4. IZPITNI ROK (15. 9. 2005)

RAČUNSKI DEL IZPITA:

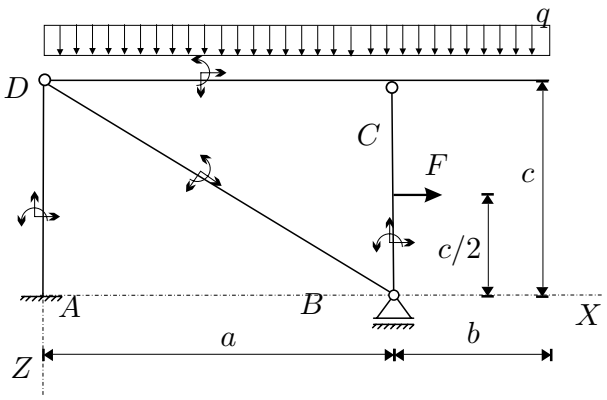
1. Janezek je na izpitu iz statike padel. Njegovi diagrami so polni napak. Pomagaj Janezku in poišči (BREZ RAČUNANJA) vse napake v spodnjih diagramih ! (OBVEZNA NALOGA! 25%)



. . . . . .

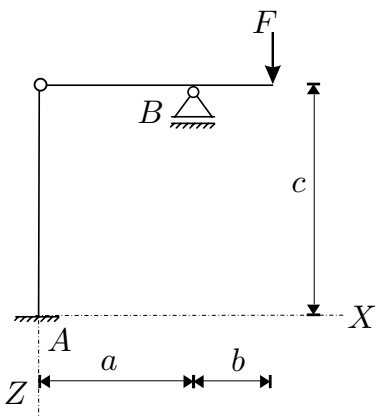
2. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

Podatki: $a = 5\,\mathrm{m}$, $b = 2\,\mathrm{m}$,
$c = 3\,\mathrm{m}$,
$q = 2\,\mathrm{kN/m}$, $F = 10\,\mathrm{kN}$.
(OBVEZNA NALOGA! 50%)



. . . . . .

3. S principom virtualnega dela za konstrukcijo na sliki izračunajte reakcije v podporah in notranji moment v točki B – M_B! (25%)



TEORETIČNI DEL IZPITA:

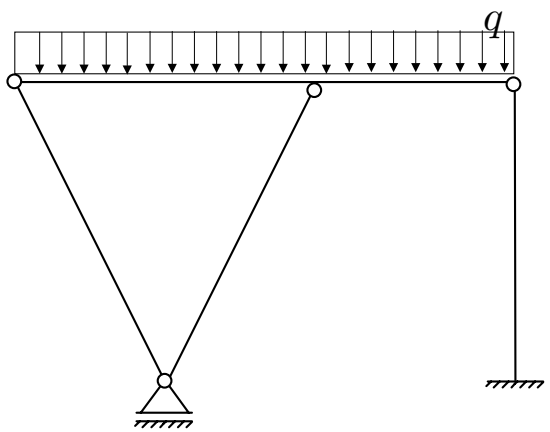
Izmed treh zastavljenih vprašanj si izberete dve, na kateri boste odgovarjali. Izbrani vprašanji jasno označite! Pišite čitljivo.

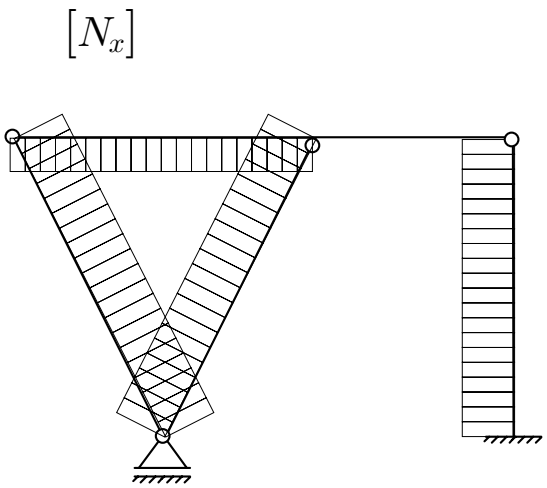
1. Vzporedna prestavitev sile! Kako lahko nadomestimo silo in moment, ki sta med seboj pravokotna? Dokaz!

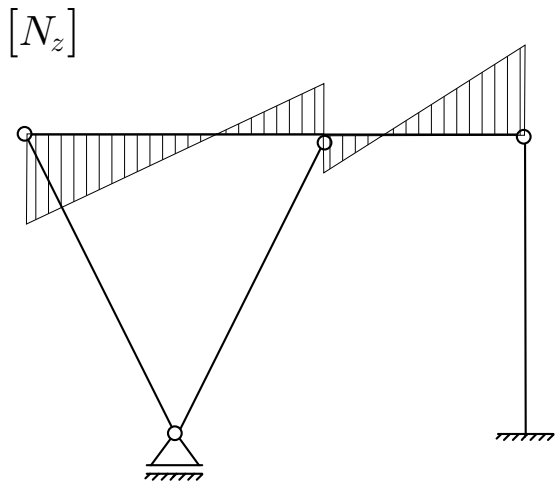
2. Ravnotežni pogoji za linijski element z ravno osjo (izpeljava diferencialnih enačb)! Ravnotežne pogoje izpeljite za raven ravninski nosilec, ki je obtežen samo z linijsko obtežbo prečno na os nosilca! Kaj so statični robni pogoji pri prostoležečem nosilcu, ki je obtežen samo z linijsko obtežbo?

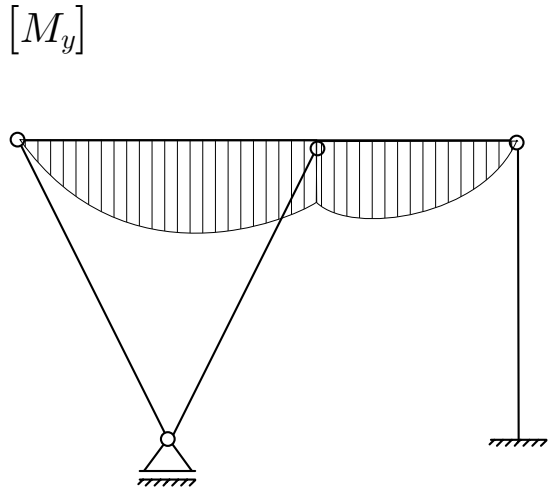
3. Opišite določanje reakcij in notranjih sil statično določenih linijskih konstrukcij z izrekom o virtualnih pomikih! Kot ilustracijo, izračunajte reakcije in notranje statične količine v enem prečnem prerezu na Gerberjevem nosilcu s konstantno prečno linijsko obtežbo!

1. Naloga: PRAVILNI DIAGRAMI









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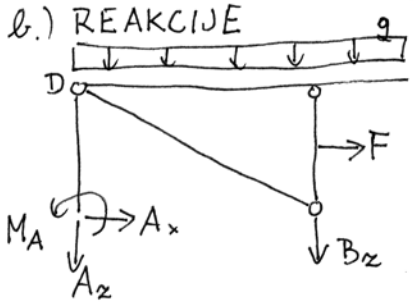
2. NALOGA

a.) $\tilde{n}_{PS} = 3\cdot 4 - 3 - 1 - 2\cdot 2 - 2\cdot(3-1) = 0$

b.) REAKCIJE



$\Sigma X: \quad A_x + F = 0 \quad \boxed{A_x = -10\,kN}$

$\Sigma Z: \quad A_z + B_z + g(a+b) = 0$

$\Sigma M^A_i: \quad -B_z\cdot a - F\cdot\frac{c}{2} - g(a+b)\frac{a+b}{2} + M_A = 0$

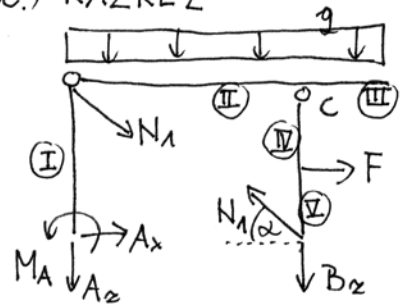
DODATNA ENAČBA

$\Sigma M^D_{AD}: \quad A_x\cdot c + M_A = 0 \quad \boxed{M_A = 30\,kNm}$

$\boxed{B_z = -6{,}8\ kN}$

$\boxed{A_z = -7{,}2\,kN}$

c.) RAZREZ



$\Sigma M^C_{BC}: \quad F\cdot\frac{c}{2} - N_1\cos\alpha\, c = 0$

$N_1 = \frac{F}{2\cos\alpha} \quad \boxed{N_1 = 5{,}83\ kN}$

$tg\,\alpha = \frac{3}{5}$

d.) NOTRANJE SILE PO POLJIH

polje (I) $x\in[0,3]$

$\Sigma x: \ N_x = A_z$

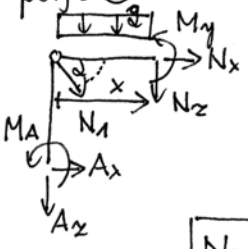
$\Sigma z: \ N_z = -A_x$

$\Sigma M: \ M_y = -M_A - A_x\cdot x$

$\boxed{N_x = -7{,}2\,kN}$ $\boxed{N_z = 10\,kN}$

$\boxed{M_y = -30 + 10x}$

polje (II) $x\in[0,5]$



$\Sigma x: \ N_x = -A_x - N_1\cos\alpha$

$\Sigma z: \ N_z = -A_z - gx - N_1\sin\alpha$

$\Sigma M: \ M_y = -M_A - g\cdot x\cdot\frac{x}{2} - A_z x - N_1\sin\alpha\, x - A_x c$

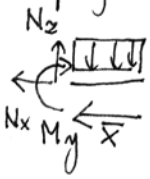
$\boxed{N_x = 5\,kN}$ $\boxed{N_z = 4{,}2 - 2x}$

$\boxed{M_y = 4{,}2x - x^2}$

$x = 2{,}1$ (ekstrem)

$\boxed{M_y(2{,}1) = 4{,}4\,kNm}$

polje (III) $\bar{x}\in[0,2]$



$\Sigma x: \ N_x = 0$

$\Sigma z: \ N_z = g\bar{x}$

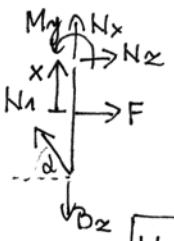
$\Sigma M: \ M_y = -g\frac{\bar{x}^2}{2}$

$\boxed{N_x = 0}$ $\boxed{N_z = 2\bar{x}}$

$\boxed{M_y = -\bar{x}^2}$

$\boxed{M_y(2) = -4\,kNm}$

polje (IV) $x\in[0,1{,}5]$



$\Sigma x: \ N_x = B_z - N_1\sin\alpha$

$\Sigma z: \ N_z = -F + N_1\cos\alpha$

$\Sigma M: \ M_y = -Fx + N_1\cos\alpha\left(\frac{c}{2} + x\right)$

$\boxed{N_x = -9{,}8\,kN}$

$\boxed{N_z = -5\,kN}$

$\boxed{M_y = 7{,}5 - 5x}$

$\boxed{M_y(1{,}5) = 0}$

polje (V) $x\in[0,1{,}5]$

$\Sigma x: \ N_x = B_z - N_1\sin\alpha$

$\Sigma z: \ N_z = +N_1\cos\alpha$

$\Sigma M: \ M_y = N_1\cos\alpha\, x$

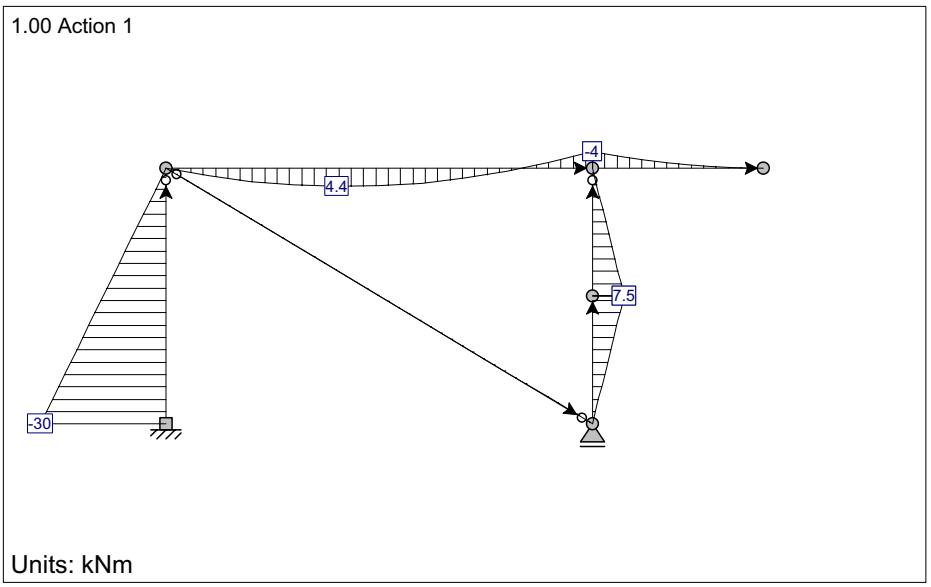
$\boxed{N_x = -9{,}8\,kN}$

$\boxed{N_z = 5\,kN}$

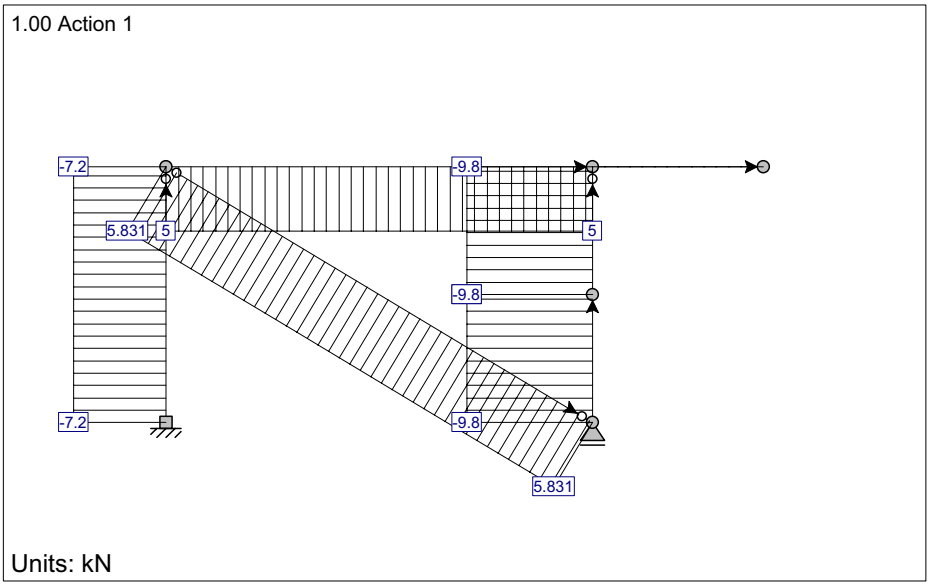
$\boxed{M_y = 5x}$

$\boxed{M_y(1{,}5) = 7{,}5\,kNm}$

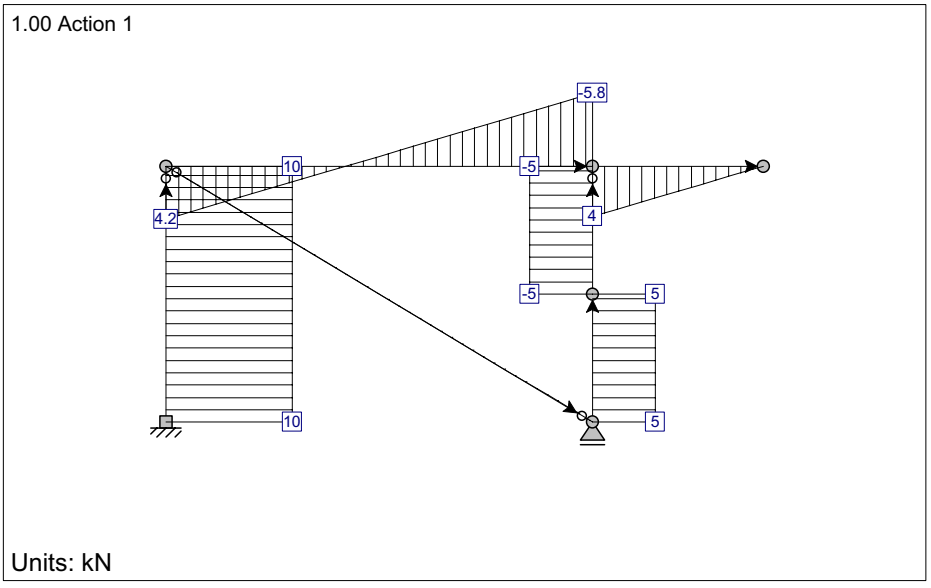
LC1: Load case 2: Bending Moments My



LC1: Load case 2: Axial Forces Fx



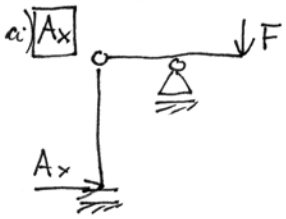
LC1: Load case 2: Shear Forces Fz



STATIKA - UNI 15.9.2005

3. NALOGA

a.) A_x

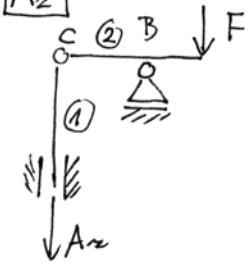


$$\delta W = A_x \delta u_A + F \delta w_F = 0$$

$$\delta w_F = 0 \quad \Rightarrow \quad A_x \delta u_A = 0$$

$$\Rightarrow \boxed{A_x = 0}$$

b.) A_z



$$\delta W = A_z \delta w_A + F \delta w_F = 0$$

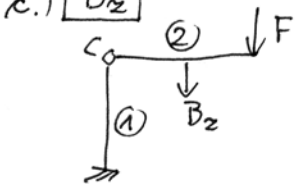
$$\left.\begin{aligned} \delta w_C &= \delta w_A \\ \delta w_F &= \delta w_C - (a+b)\delta \varphi_C^{②} \\ \delta w_B &= 0 \end{aligned}\right\} \quad \delta w_B = \delta w_C - a\delta \varphi_C^{②} \quad (= 0)$$

$$\Rightarrow \quad \delta w_F = \delta w_A - \frac{a+b}{a}\delta w_A$$

$$\delta w_F = -\frac{b}{a}\delta w_A$$

$$A_z \delta w_A - \frac{b}{a}\delta w_A \cdot F = 0 \quad \Rightarrow \quad \boxed{A_z = \frac{b}{a}F}$$

c.) B_z

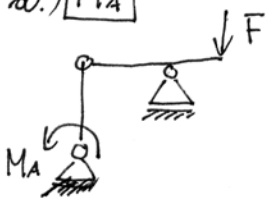


$$\delta W = B_z \delta w_B + F \delta w_F = 0$$

$$\left.\begin{aligned} \delta w_C &= 0 \\ \delta w_B &= \delta w_C - a\delta \varphi_C^{②} \\ \delta w_F &= \delta w_C - (a+b)\delta \varphi_C^{②} \end{aligned}\right\} \quad \delta w_F = + \frac{a+b}{a}\delta w_B$$

$$\left(B_z + F\frac{a+b}{a}\right)\delta w_B = 0 \quad \Rightarrow \quad \boxed{B_z = -\frac{a+b}{a}F}$$

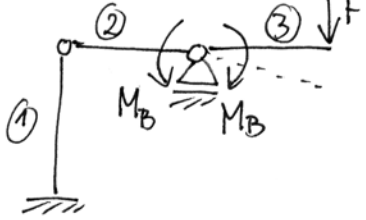
d.) M_A



$$\delta W = M_A \delta \varphi^{①} + F \delta w_F = 0$$

$$\delta w_F = 0 \quad \Rightarrow \quad \boxed{M_A = 0}$$

e) M_B (notranji moment)



$$\delta W = M_B \delta \varphi_B^{②} - M_B \delta \varphi_B^{③} + F \delta w_F = 0$$

$$\underline{\delta \varphi_B^{②} = 0}$$

$$\delta w_F = \delta w_B - b\,\delta \varphi_B^{③} \quad (\delta w_B = 0)$$

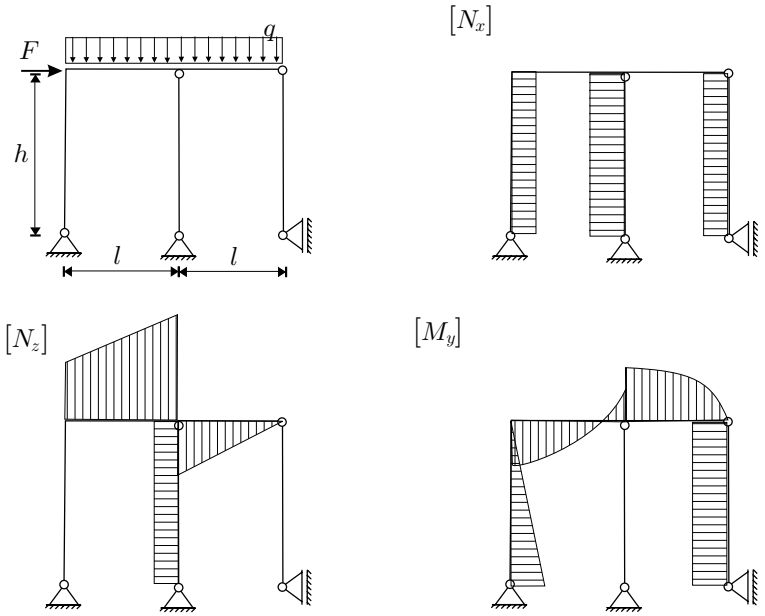
$$\boxed{-M_B \delta \varphi_B^{③} - Fb\,\delta \varphi_B^{③} = 0}$$

$$\Rightarrow \quad \boxed{M_B = -Fb}$$

STATIKA (UNI) - 2. IZREDNI IZPITNI ROK (7. 12. 2005)

RAČUNSKI DEL IZPITA:

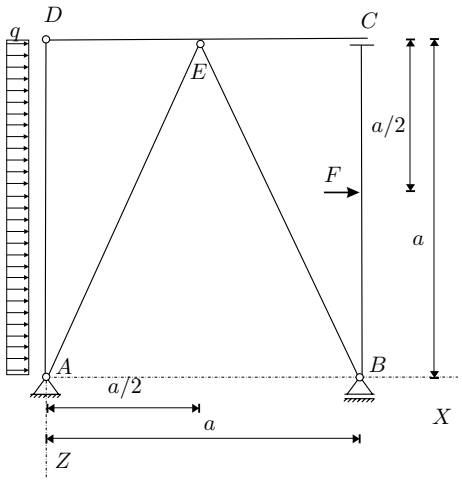
1. Janezek je na izpitu iz statike padel. Njegovi diagrami so polni napak. Pomagaj Janezku in poišči (BREZ RAČUNANJA) vse napake v spodnjih diagramih ! (OBVEZNA NALOGA! 25%)



. . . . . .

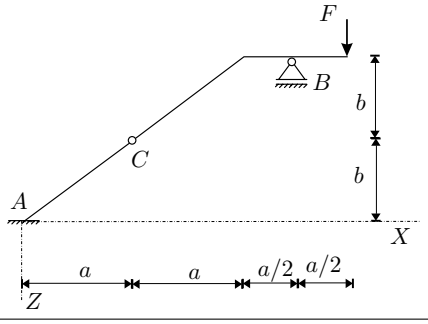
2. Za konstrukcijo na sliki izračunajte stopnjo statične nedoločenosti, reakcije in notranje statične količine (N_x, N_z, M_y)! Rezultate notranjih statičnih količin prikažite z diagrami!

Podatki: $a = 3\,\mathrm{m}$, $q = 5\,\mathrm{kN/m}$, $F = 10\,\mathrm{kN}$.
(OBVEZNA NALOGA! 50%)



. . . . . .

3. S principom virtualnega dela za konstrukcijo na sliki izračunajte reakcije v podporah in notranji moment v točki B – M_B! (25%)



TEORETIČNI DEL IZPITA:

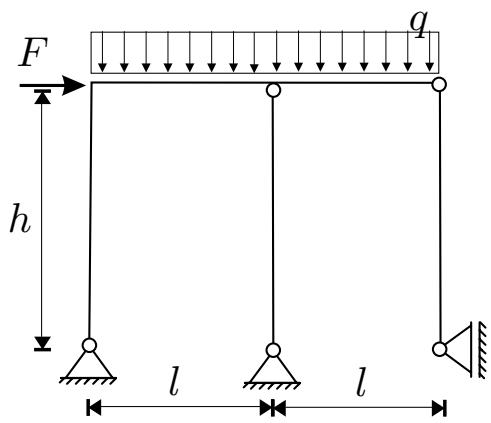
Izmed treh zastavljenih vprašanj si izberete dve, na kateri boste odgovarjali. Izbrani vprašanji jasno označite! Pišite čitljivo.

1. Računski modeli za opis medsebojnega vpliva med telesi!

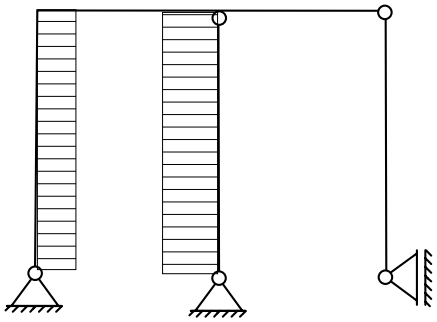
2. Pomiki in zasuki togega telesa (izpeljava enačb za ravninsko gibanje togega telesa)!

3. Izpeljite in opišite izraz za število odvzetih prostostnih stopenj, ki jih vez odvzame k nepovezanim telesom! Obravnavajte tudi primer, ko imajo vsa telesa na mestu vezi enake nekatere kinematične količine, preostale kinematične količine pa so možne za vsa telesa! (ilustracija s karakterističnimi primeri)

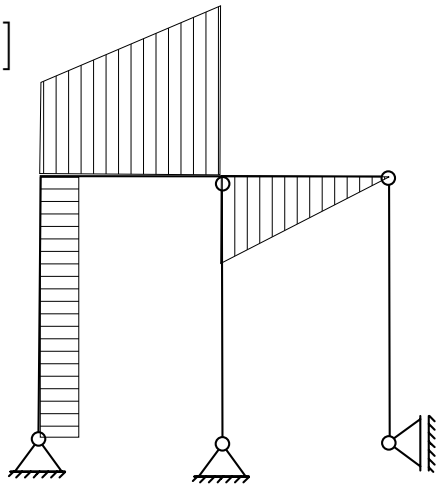
1. Naloga: PRAVILNI DIAGRAMI



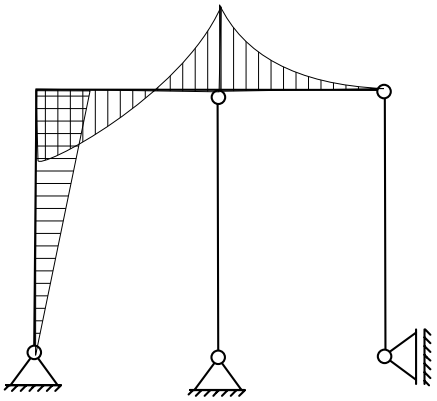
$[N_x]$



$[N_z]$



$[M_y]$

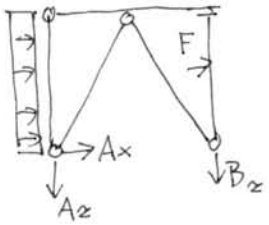


STATIKA - UNI 7. 12. 2005

2. NALOGA

a.) $\sum m_{PS} = 5 \cdot 3 - 2 - 1 - 3 \cdot 2 - 2 \cdot 2 \cdot 2 = 0$

b.) REAKCIJE



$\Sigma X: \; A_x + F + q \cdot a = 0$

$\Sigma Z: \; A_z + B_z = 0$

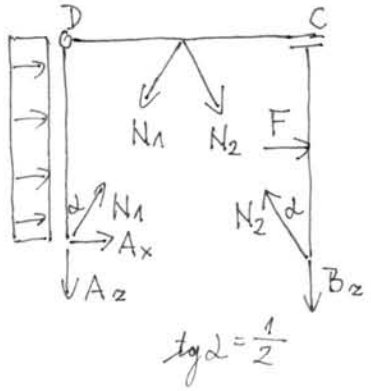
$\Sigma M_A: \; -B_z \cdot a - F \cdot \frac{a}{2} - q \cdot a \cdot \frac{a}{2} = 0$

$B_z = -12{,}5 \text{ kN}$

$A_z = 12{,}5 \text{ kN}$

$A_x = -25 \text{ kN}$

c.) IZREŽEMO PALICE



$\Sigma M^D_{AD}: \; N_1 \cdot \sin\alpha \cdot a + A_x \cdot a + q \cdot a \cdot \frac{a}{2} = 0$

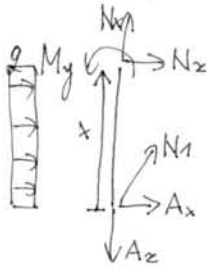
$N_1 = \frac{17{,}5}{\sin\alpha} = 39{,}13 \text{ kN}$

$\Sigma X_{BC}: \; F_1 - N_2 \cdot \sin\alpha = 0$

$N_2 = \frac{F}{\sin\alpha} = 22{,}36 \text{ kN}$

d.) NOTRANJE SILE PO POLJIH

d1) polje AD



$N_x = A_z - N_1 \cdot \cos\alpha$

$N_z = -A_x - N_1 \sin\alpha - qx$

$M_y = -A_x x - N_1 \sin\alpha \, x - q\frac{x^2}{2}$

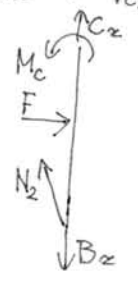
$N_x = -22{,}5 \text{ kN}$

$N_z = 7{,}5 - 5x$ $\quad N_z(3) = -7{,}5 \text{ kN}$

$M_y = 7{,}5x - 2{,}5x^2$

$M_y(1{,}5) = 5{,}6 \text{ kNm}$ (desnem)

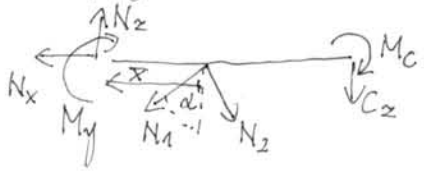
sile v vezi C:



$C_z = B_z - N_2 \cdot \cos\alpha$ $\quad C_z = -32{,}5 \text{ kN}$

$M_c = -F \cdot a/2 + N_2 \cdot \sin\alpha \, a$ $\quad M_c = 15 \text{ kNm}$

d2.) polje DE



$\Sigma x: \; -N_x - N_1 \cdot \sin\alpha + N_2 \sin\alpha = 0$

$\Sigma z: \; N_z = C_z + N_1 \cdot \cos\alpha + N_2 \cos\alpha$

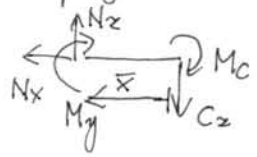
$\Sigma M^T: \; M_y = -M_c - C_z(a/2 + \bar{x}) - N_1 \cdot \cos\alpha \, \bar{x} - N_2 \cos\alpha \, \bar{x}$

$N_x = -7{,}5 \text{ kN}$

$N_z = 22{,}5 \text{ kN}$

$M_y = 33{,}75 - 22{,}5\bar{x}$ $\quad M_y(1{,}5) = 0$

d3.) polje CE



$\Sigma x: N_x = 0$

$\Sigma z: N_z = C_z$

$\Sigma M: M_y = -M_c - C_z \bar{x}$

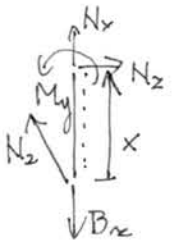
$N_x = 0$

$N_z = -32{,}5$ kN

$M_y = -15 + 32{,}5\,\bar{x}$

$M_y(1{,}5) = 33{,}75$ kNm

d4) polje BF



$N_x = B_z - N_2 \cdot \cos\alpha$

$N_z = N_2 \cdot \sin\alpha$

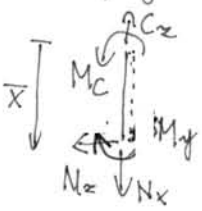
$M_y = N_2 \cdot \sin\alpha \, x$

$N_x = -32{,}5$ kN

$N_z = 10$ kN

$M_y = 10\,x$ $\quad M_y(1{,}5) = 15$ kN

d5) polje EF



$N_x = C_z$

$N_z = 0$

$M_y = +M_c$

$N_x = -32{,}5$ kN

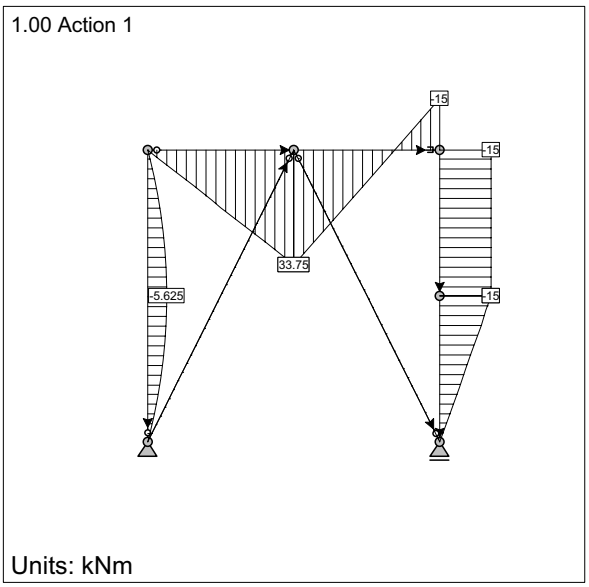
$N_z = 0$

$M_y = +15$ kNm

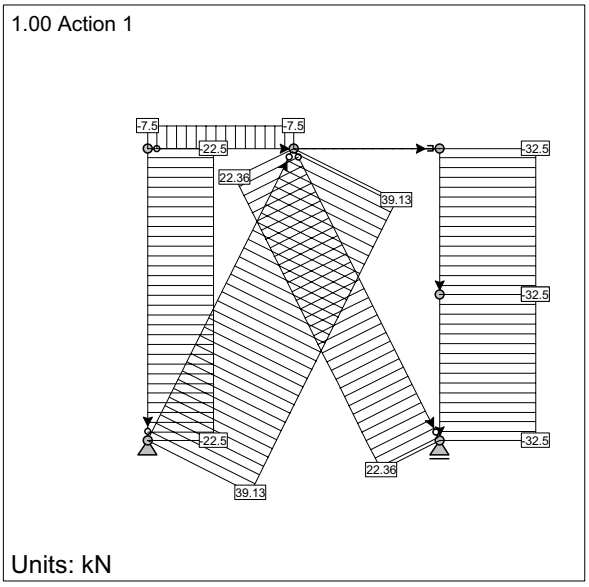
e.) DIAGRAMI

glej naslednjo stran

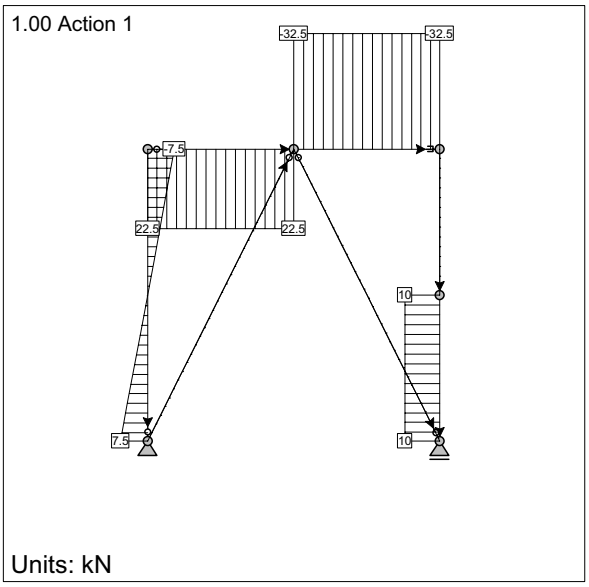
LC1: Load case 2: Bending Moments My



LC1: Load case 2: Axial Forces Fx



LC1: Load case 2: Shear Forces Fz



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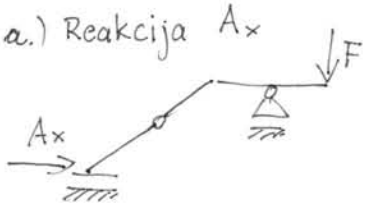
3. NALOGA

a.) Reakcija A_x

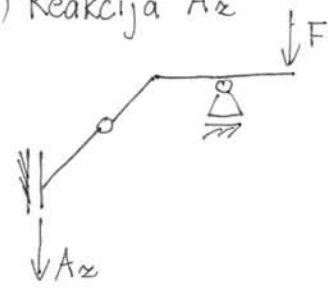


$$\delta W = A_x \delta u_A + F \delta w_F = 0$$

$\delta w_F = 0$

δu_A je poljuben $\Rightarrow \boxed{A_x = 0}$

b.) Reakcija A_z



$$\delta W = A_z \delta w_A + F \delta w_F = 0$$

$$\delta w_C = \delta w_A - a \underbrace{\delta \varphi_A}_{=0} \qquad \boxed{\delta w_C = \delta w_A}$$

$$\delta u_C = \underbrace{\delta u_A}_{=0} - b \underbrace{\delta \varphi_A}_{=0} \qquad \delta u_C = 0$$

$$\delta w_F = \delta w_C - 2a \delta \varphi_C^{(2)}$$

$$\delta u_F = \underbrace{\delta u_C}_{=0} - b \delta \varphi_C^{(2)}$$

$$\delta w_B = \delta w_C - \frac{3}{2} a \delta \varphi_C^{(2)}$$

$\delta w_B = 0$, $\delta w_C = \delta w_A$

$$\Rightarrow \boxed{\delta \varphi_C^{(2)} = \frac{2}{3a} \delta w_A}$$

$$\delta w_F = \delta w_A - \frac{4}{3} \delta w_A$$

$$\boxed{\delta w_F = -\frac{1}{3} \delta w_A}$$

$$\Rightarrow \left(A_z - \frac{1}{3} F\right) \delta w_A = 0 \qquad \boxed{A_z = \frac{F}{3}}$$

c.) Moment M_A

$$\delta W = M_A \delta \varphi_A + F \delta w_F = 0$$

$$\delta u_C = \underbrace{\delta u_A}_{=0} - b \delta \varphi_A \qquad \delta u_F = \delta u_C - b \delta \varphi_C^{(2)}$$

$$\delta w_C = \underbrace{\delta w_A}_{=0} - a \delta \varphi_A \qquad \delta w_F = \delta w_C - 2a \delta \varphi_C^{(2)}$$

$$\delta w_B = \delta w_C - \frac{3a}{2} \delta \varphi_C^{(2)}$$

$\delta w_B = 0$

$$-a \delta \varphi_A - \frac{3a}{2} \delta \varphi_C^{(2)} = 0$$

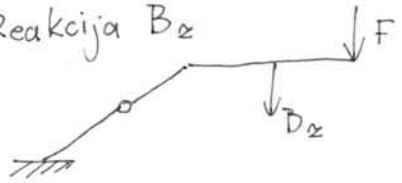
$$\boxed{\delta \varphi_C^{(2)} = -\frac{2}{3} \delta \varphi_A}$$

$$\delta w_F = -a \delta \varphi_A + \frac{4a}{3} \delta \varphi_A = \frac{1a}{3} \delta \varphi_A$$

$$\boxed{M_A \delta \varphi_A + \frac{F \cdot a}{3} \delta \varphi_A = 0}$$

$$\Rightarrow \boxed{M_A = -\frac{F \cdot a}{3}}$$

d.) Reakcija B_x



$$\delta W = B_x \delta w_B + F \delta w_F = 0$$

$\delta w_B = \delta w_C - \frac{3a}{2} \delta \varphi_C^{②}$ ($\delta w_C = 0$)

$\delta u_B = \delta u_C - b \delta \varphi_C^{②}$ ($\delta u_C = 0$)

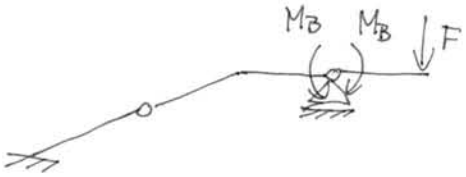
$\delta w_F = \delta w_C - 2a \delta \varphi_C^{②}$ ($\delta w_C = 0$)

$\delta u_F = \delta u_C - b \delta \varphi_C^{②}$ ($\delta u_C = 0$)

$$\delta W = B_x \cdot \left(-\frac{3a}{2}\right) \delta \varphi_C^{②} - 2aF \delta \varphi_C^{②} = 0$$

$$\Rightarrow \boxed{B_x = -\frac{4}{3} F}$$

e.) Notranji moment v B



$$\delta W = M_B \cdot \delta \varphi_B^{①} - M_B \delta \varphi_B^{②} + F \cdot \delta w_F = 0$$

$\delta \varphi_B^{①} = 0$

$\delta w_F = \delta w_B - \frac{a}{2} \delta \varphi_B^{②}$ ($\delta w_B = 0$)

$$-M_B \delta \varphi_B^{②} - \frac{F}{2} a \delta \varphi_B^{②} = 0$$

$$\boxed{M_B = -\frac{F}{2} a}$$