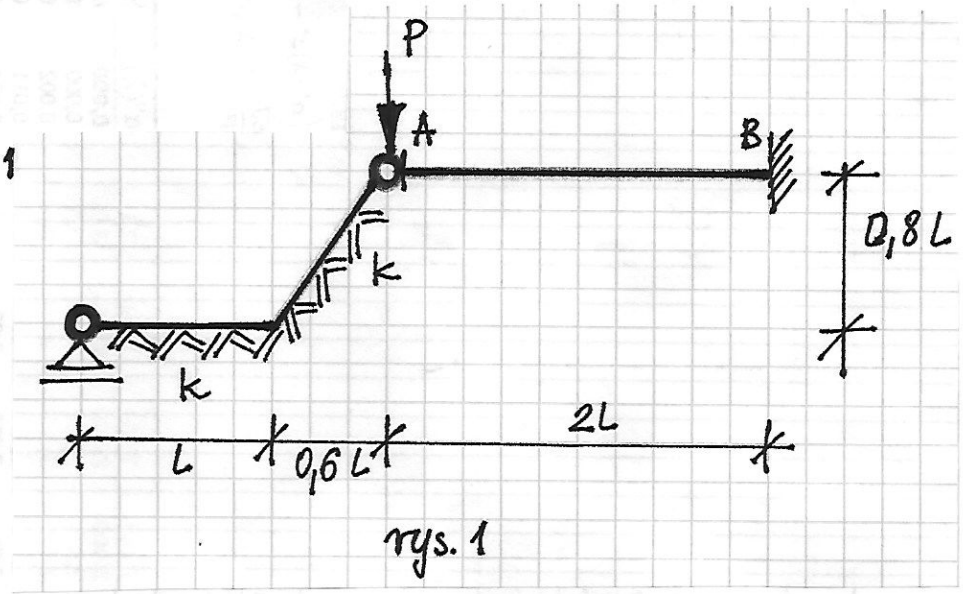
Egzamin z Mechaniki Konstrukcji (MK IPB), 11.09.2017
studia stacjonarne

NAZWISKO, Imię				
rok akademicki zaliczenia ćwiczeń		nr albumu	grupa (IPB / BZ)	tryb studiów (ST / NST)
ocena zadania 1	ocena zadania 2	ocena zadania 3	ocena egzaminu	ocena łączna

Zadanie 1.

$EJ = const.,\qquad k = 0{,}0064\dfrac{EJ}{l^4}$

Oblicz kąt obrotu w punkcie A ramy z rys. 1 korzystając z funkcji ugięcia pręta AB.

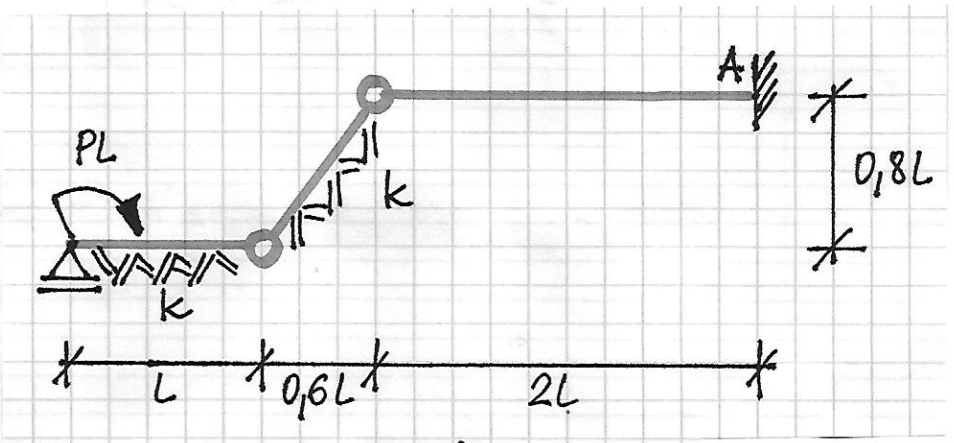


rys. 1

Zadanie 2.

$EJ = const.,\qquad k = 0{,}0064\dfrac{EJ}{l^4}$

Oblicz moment w utwierdzeniu A w ramie z rys. 2 korzystając z tw. Bettiego.

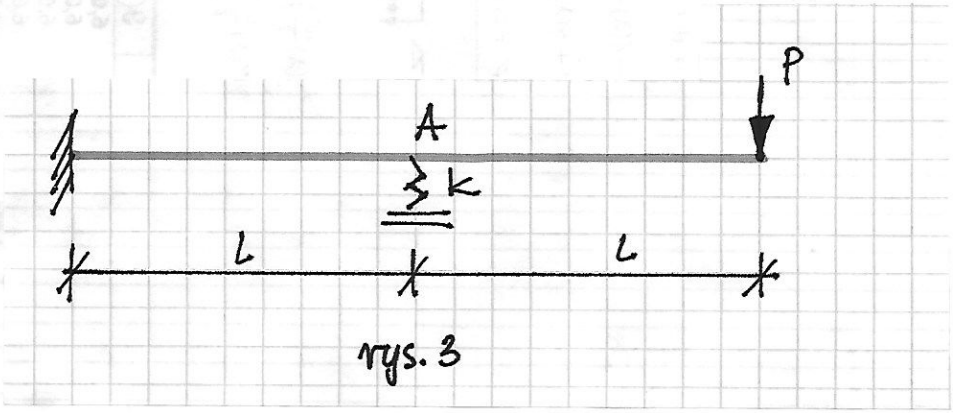


rys. 2

Zadanie 3.

$EJ = const.$

Wyznacz wartość współczynnika k, dla którego kąt obrotu w punkcie A belki z rys. 3 jest równy $\varphi_A = \frac{Pl^2}{2EJ}$.



rys. 3

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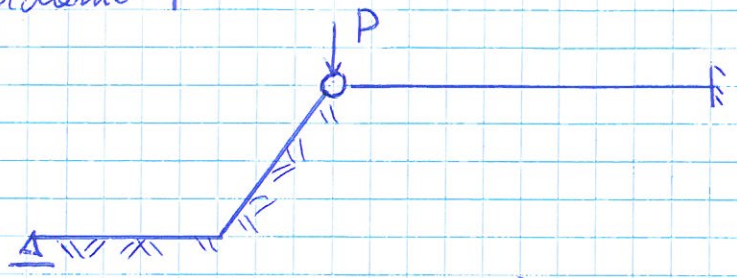
Zadanie 1



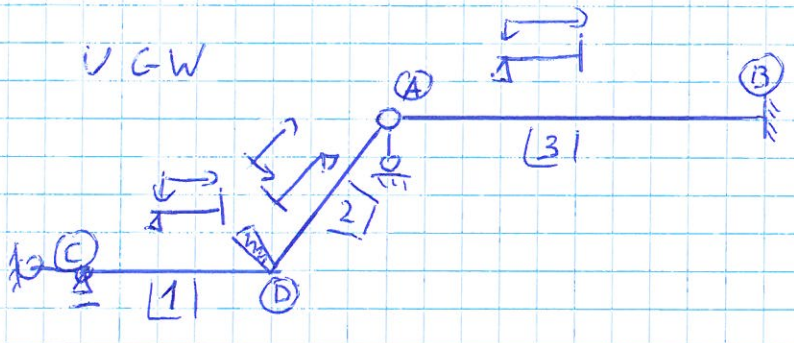
$\lambda_1 = 0{,}2$

$\lambda_2 = 0{,}2$

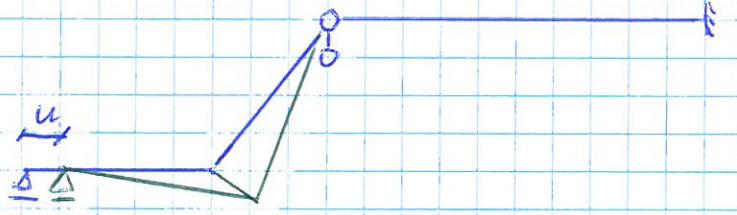
$\lambda_3 = 0$

$q_1 = \begin{bmatrix} \varphi_D \\ \frac{u}{L} \\ \frac{v}{L} \end{bmatrix}$

UGW

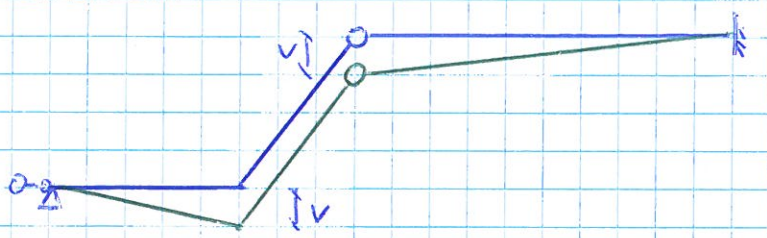


PD u:



Pręt	$^*w$	w^*	u
1	0	$\frac{3}{4}u$	u
2	$\frac{5}{4}u$	0	0
3	0	0	0

PP v:



Pręt	$^*w$	w^*	u
1	0	v	0
2	$\frac{3}{5}v$	$\frac{3}{5}v$	$-\frac{4}{5}v$
3	v	0	0

RR:

$$\begin{cases} \bar{\Phi}_D^1 + \bar{\Phi}_D^2 = 0 \\ -\left(\bar{W}_D^1 \cdot \frac{3}{4}\bar{u} + \bar{W}_D^2 \cdot \frac{5}{4}\bar{u}\right) = 0 \\ -\left(\bar{W}_D^1 \bar{v} + \left(\bar{W}_D^2 + \bar{W}_A^2\right)\frac{3}{5}\bar{v} + \bar{W}_A^3 \bar{v}\right) + P\bar{v} = 0 \end{cases}$$

$$\bar{\Phi}_D^1 = \frac{EJ}{L}\left(4'(0{,}2)\varphi_D - \vartheta'(0{,}2)\left(\frac{3}{4}\frac{u}{L} + \frac{v}{L}\right)\right) = \frac{EJ}{L}\left(3\varphi_D - 2{,}250\frac{u}{L} - 3{,}001\frac{v}{L}\right)$$

$$\bar{\Phi}_D^2 = \frac{EJ}{L}\left(4'(0{,}2)\varphi_D + \vartheta'(0{,}2)\left(\frac{5}{4}\frac{u}{L} + \frac{3}{5}\frac{v}{L}\right) - \vartheta'(0{,}2)\left(\frac{3}{5}\frac{v}{L}\right)\right) =$$

$$= \frac{EJ}{L}\left(3\varphi_D + 3{,}751\frac{u}{L}\right)$$

$$\bar{W}_D^1 = -\frac{EJ}{l^2}\left(v'(0,2)\,\varphi_D - \gamma'(0,2)\left(\frac{3}{4}\frac{u}{l} + \frac{v}{l}\right)\right) = \frac{EJ}{l^2}\left(-3{,}001\,\varphi_D + 2{,}252\frac{u}{l} + 3{,}003\frac{v}{l}\right)$$

$$\bar{W}_D^2 = \frac{EJ}{l^2}\left(v'(0,2)\,\varphi_D + \gamma'(0,2)\left(\frac{5}{4}\frac{u}{l} + \frac{3}{5}\frac{v}{l}\right) - \varepsilon'(0,2)\frac{3}{5}\frac{v}{l}\right) =$$

$$= \frac{EJ}{l^2}\left(3{,}001\,\varphi_D + 3{,}754\frac{u}{l} + 0{,}02\frac{v}{l}\right)$$

$$\bar{W}_A^2 = -\frac{EJ}{l^2}\left(\delta'(0,2)\,\varphi_D + \varepsilon'(0,2)\left(\frac{5}{4}\frac{u}{l} + \frac{3}{5}\frac{v}{l}\right) - \chi'(0,2)\frac{3}{5}\frac{v}{l}\right) =$$

$$\frac{EJ}{l^2}\left(-3\,\varphi_D - 3{,}749\frac{u}{l} + 0{,}001\frac{v}{l}\right)$$

$$\bar{W}_A^3 = \frac{3EJ}{4l^2}\left(-\frac{v}{2l}\right) = \frac{EJ}{l^2}\left(+\frac{3}{8}\frac{v}{l}\right)$$

$$\frac{EJ}{l}\begin{bmatrix} 6 & 1{,}5 & -3 \\ 1{,}5 & 6{,}382 & 2{,}255 \\ -3 & 2{,}255 & 3{,}38 \end{bmatrix}\begin{bmatrix} \varphi_D \\ \frac{u}{l} \\ \frac{v}{l} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} Pl \Rightarrow \begin{aligned} \varphi_D &= 1{,}66\,\frac{Pl^2}{EJ} \\ \frac{u}{l} &= -1{,}329\,\frac{Pl^2}{EJ} \\ \frac{v}{l} &= 2{,}656\,\frac{Pl^2}{EJ} \end{aligned}$$

$$w(\xi) = A_0 + A_1\xi + A_2\xi^2 + A_3\xi^3$$

RB:

$w(0) = v$ $\quad w(1) = 0$

$M(0) = 0$ $\quad \varphi(1) = 0$

$$\varphi(\xi) = \frac{1}{2l}\,w'(\xi)$$

$$M(\xi) = -\frac{EJ}{(2l)^2}\,w''(\xi)$$

$$w(\xi) = (2{,}656 - 3{,}984\xi + 1{,}328\xi^3)\,\frac{Pl^3}{EJ}$$

$$\varphi(\xi) = 1{,}992\,(\xi^2 - 1)\,\frac{Pl^2}{EJ}$$

$$\varphi(0) = -1{,}992\,\frac{Pl^2}{EJ}$$

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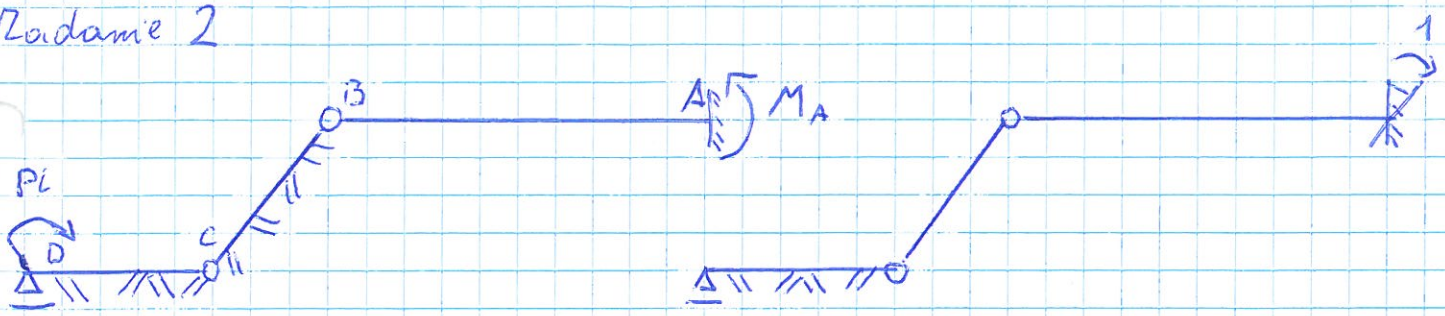
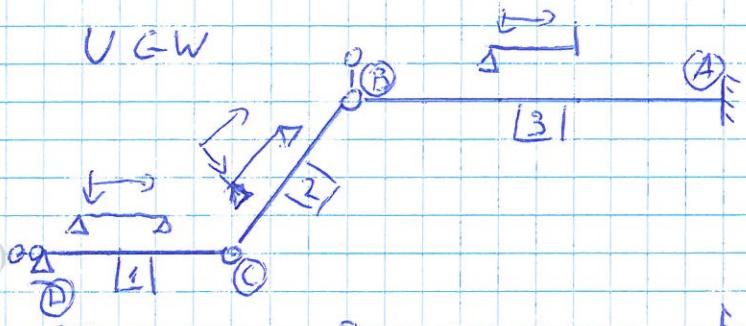
Zadanie 2



Z tw Bettiego:

$-M_A \cdot 1 + PL\,\varphi_D = 0 \Rightarrow M_A = PL\,\varphi_D$

UGW



$r_1 = 0,2$

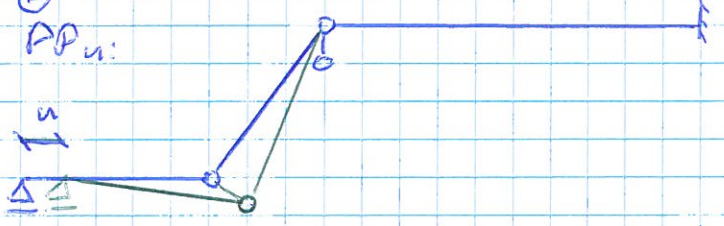
$r_2 = 0,7$

$r_3 = 0$

$q_1 = \begin{bmatrix} \frac{u}{l} \\ \frac{v}{l} \end{bmatrix}$

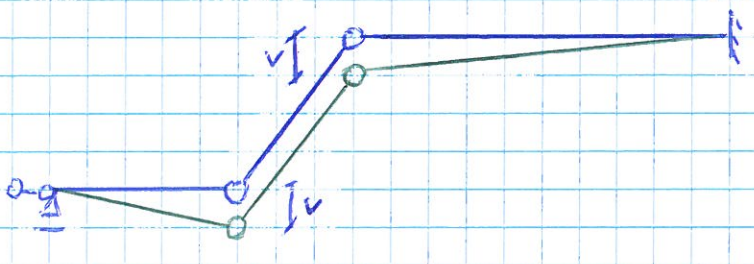
Pręt	$^*w$	w^*	u
1	0	$\frac{3}{4}u$	u
2	$\frac{5}{4}u$	0	0
3	0	0	0

PP u:



Pręt	$^*w$	w^*	u
1	0	v	0
2	$\frac{3}{5}v$	$\frac{3}{5}v$	$-\frac{4}{5}v$
3	v	0	0

PP v:



RR:

$$\begin{cases} -\left(\bar{W}_C^1 \cdot \frac{3}{4}\bar{u} + \bar{W}_C^2 \cdot \frac{5}{4}\bar{u}\right) = 0 \\ -\left(\bar{W}_C^1 \bar{v} + \left(\bar{W}_C^2 + \bar{W}_B^2\right)\frac{3}{5}\bar{v} + \bar{W}_{13}^3 \bar{v}\right) = 0 \end{cases}$$

$\bar{W}_C^1 = \frac{EJ}{l^2}\left(0,002\frac{u}{l} + 0,002\frac{v}{l}\right)$ $\bar{W}_C^2 = \frac{EJ}{l^2}\left(0,003\frac{u}{l} + 0,002\frac{v}{l}\right)$

$\bar{W}_{13}^2 = \frac{EJ}{l^2}\left(0,001\frac{u}{l} + 0,002\frac{v}{l}\right)$ $\bar{W}_B^3 = \frac{EJ}{l^2}\left(\frac{3}{4} + \frac{3}{8}\frac{v}{l}\right)$

$$\frac{EJ}{l}\begin{bmatrix} 0,005 & 0,004 \\ 0,004 & 0,379 \end{bmatrix}\begin{bmatrix} \frac{u}{l} \\ \frac{v}{l} \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{3}{4} \end{bmatrix}\frac{EJ}{l}$$

$\frac{u}{l} = -1,760$

$\frac{v}{l} = 1,995$

Ponieważ $\bar{\Phi}_D^1 = 0,1_0$ $\bar{\Phi}_0^1 = \frac{EJ}{l}\left(\alpha'(0,2)\varphi_D - \delta'(0,2)\left(\frac{3}{4}u + v\right)\right) = 0 \Rightarrow \varphi_D = \frac{3}{4}u + v$

$\varphi_D = 0,675 \Rightarrow M_A = 0,675\,PL$

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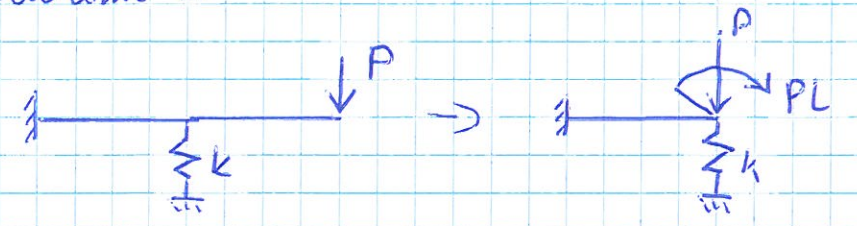
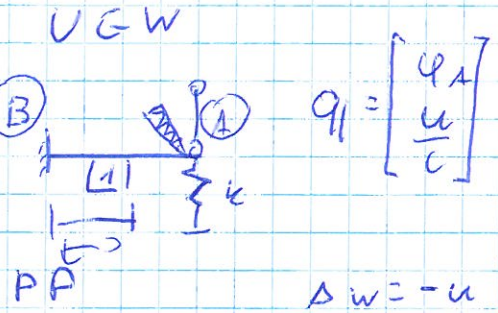
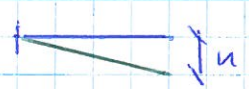
Zadanie 3





$\Delta w = -u$

$Q_w = -ku$



RR:

$$\begin{cases} -\bar{\Phi}_B^1 + Pl = 0 \\ -\bar{W}_A^1 \bar{u} + Q_w \bar{u} + P\bar{u} = 0 \end{cases} \Rightarrow \begin{cases} \bar{\Phi}_B^1 = Pl \\ \bar{W}_A^1 + ku = P \end{cases}$$

$$\bar{\Phi}_B^1 = \frac{EJ}{l}\left(4\varphi_B - 6\frac{u}{l}\right) \qquad k = \tilde{\iota}\frac{EJ}{l^3}$$

$$\bar{W}_B^1 = \frac{EJ}{l^2}\left(-6\varphi_B + 12\frac{u}{l}\right)$$

$$\frac{EJ}{l}\begin{bmatrix} 4 & -6 \\ -6 & 12+\tilde{\iota} \end{bmatrix}\begin{bmatrix} \varphi_B \\ \frac{u}{l} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} Pl$$

$$\varphi_B = \frac{1}{4}\frac{Pl^2}{EJ} + \frac{3}{2}\frac{u}{l}$$

$$-6\varphi_B + (12+\tilde{\iota})\frac{u}{l} = \frac{Pl^2}{EJ} \Rightarrow -\frac{3}{2}\frac{Pl^2}{EJ} - 9\frac{u}{l} + (12+\tilde{\iota})\frac{u}{l} = \frac{Pl^2}{EJ}$$

$$(3+\tilde{\iota})\frac{u}{l} = \frac{5}{2}\frac{Pl^2}{EJ} \qquad \varphi_B = \frac{Pl^2}{EJ} \Rightarrow \frac{u}{l} = \frac{Pl^2}{6EJ}$$

$$(3+\tilde{\iota})\frac{Pl^2}{6EJ} = \frac{5}{2}\frac{Pl^2}{EJ} \qquad \tilde{\iota} = 12 \Rightarrow k = 12\frac{EJ}{l^3}$$