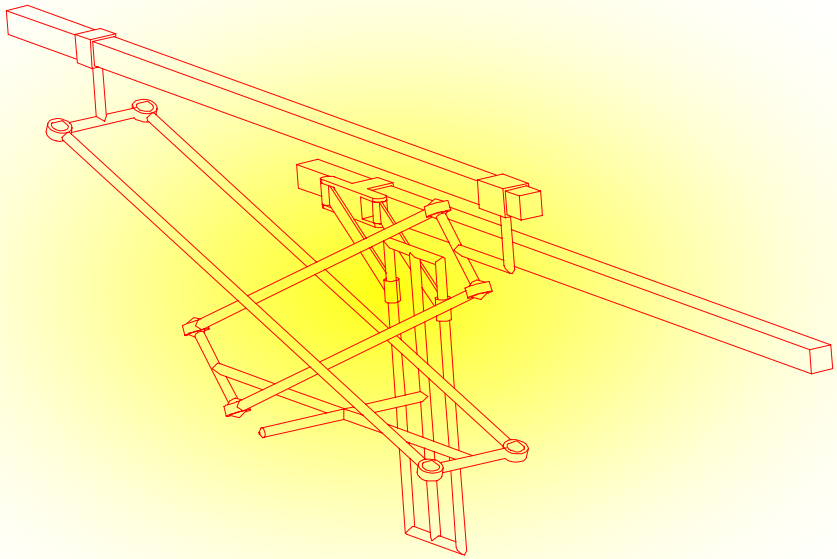
MAŠINSKI FAKULTET BEOGRAD

Katedra za proizvodno mašinstvo Mašinskog fakulteta

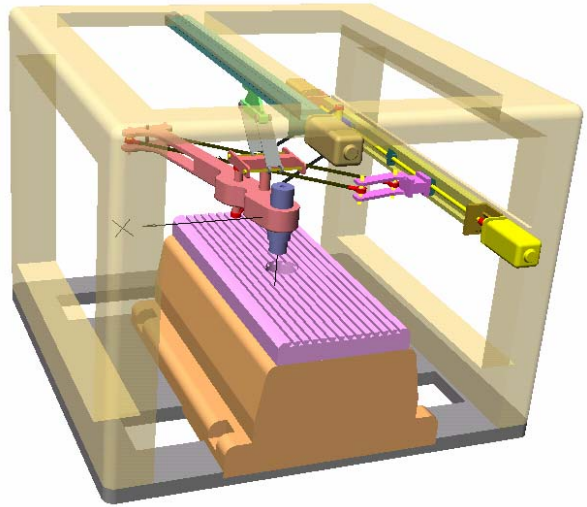


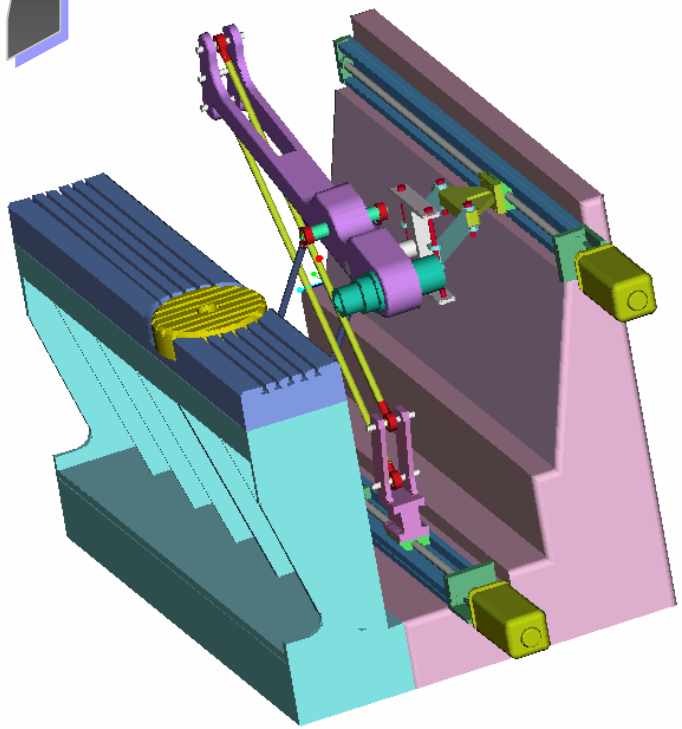
Dr Dragan Milutinović, Dr Miloš Glavonjić, Mr Saša Živanović

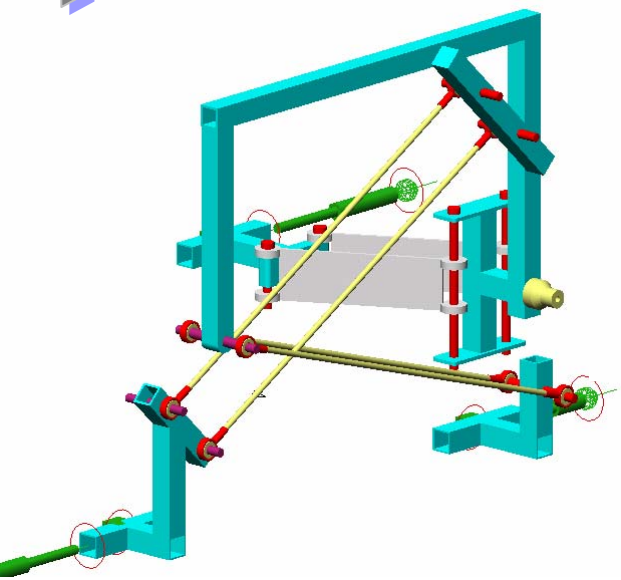
Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom

novembra, 2004. godine

PN0101-1-2-3-*

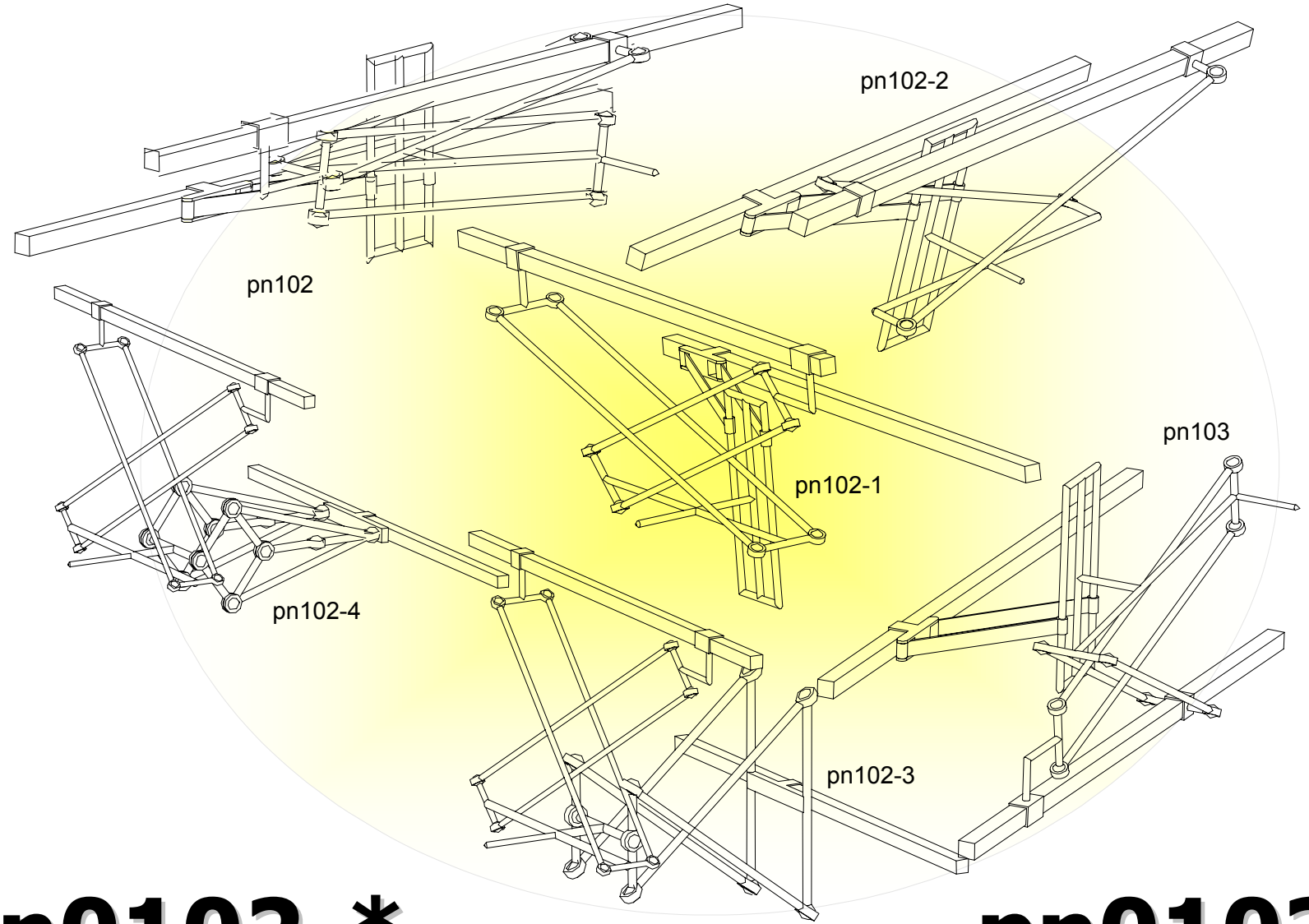






pn0101-*

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom



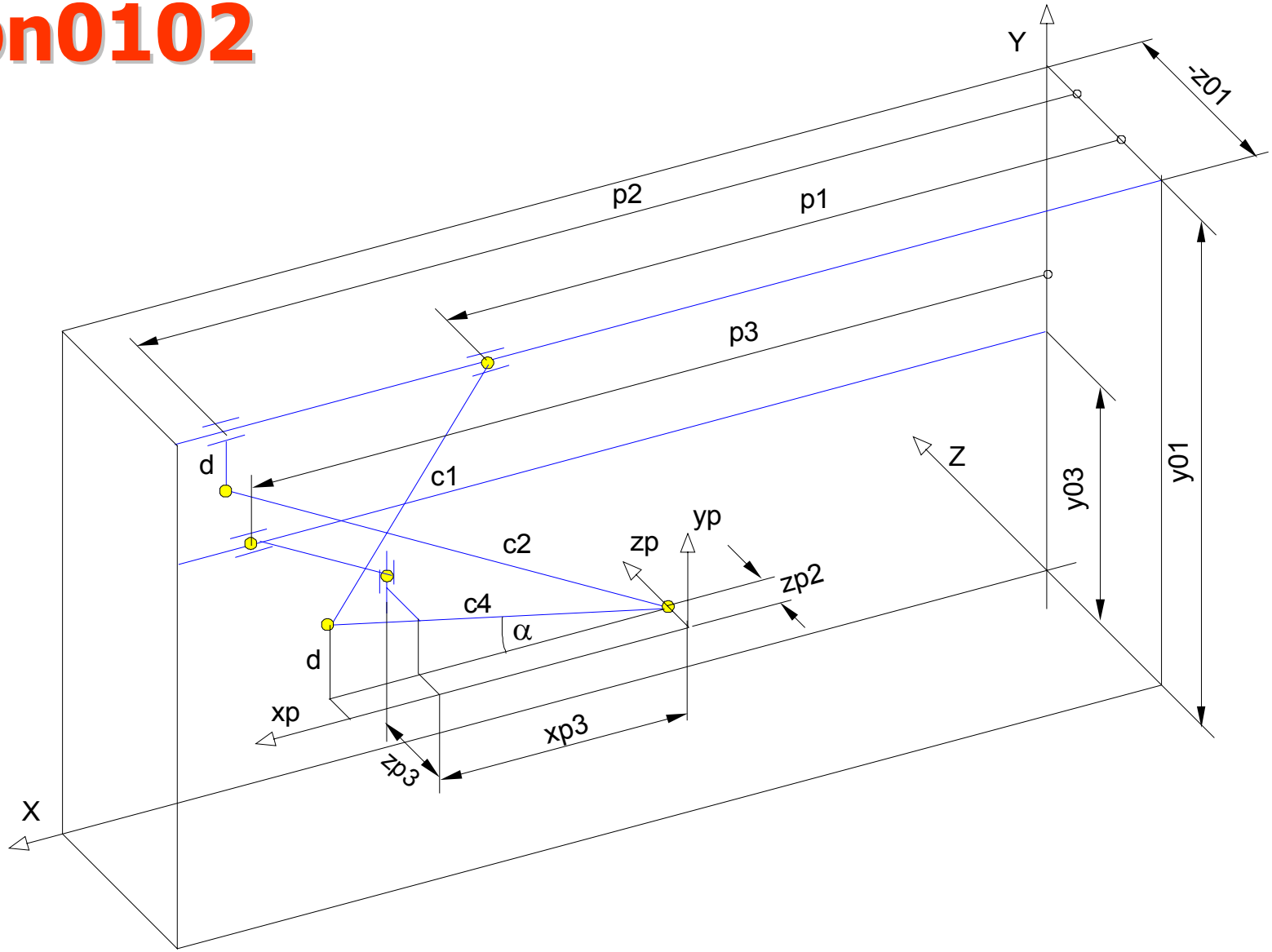
pn0102-*

pn0103-*

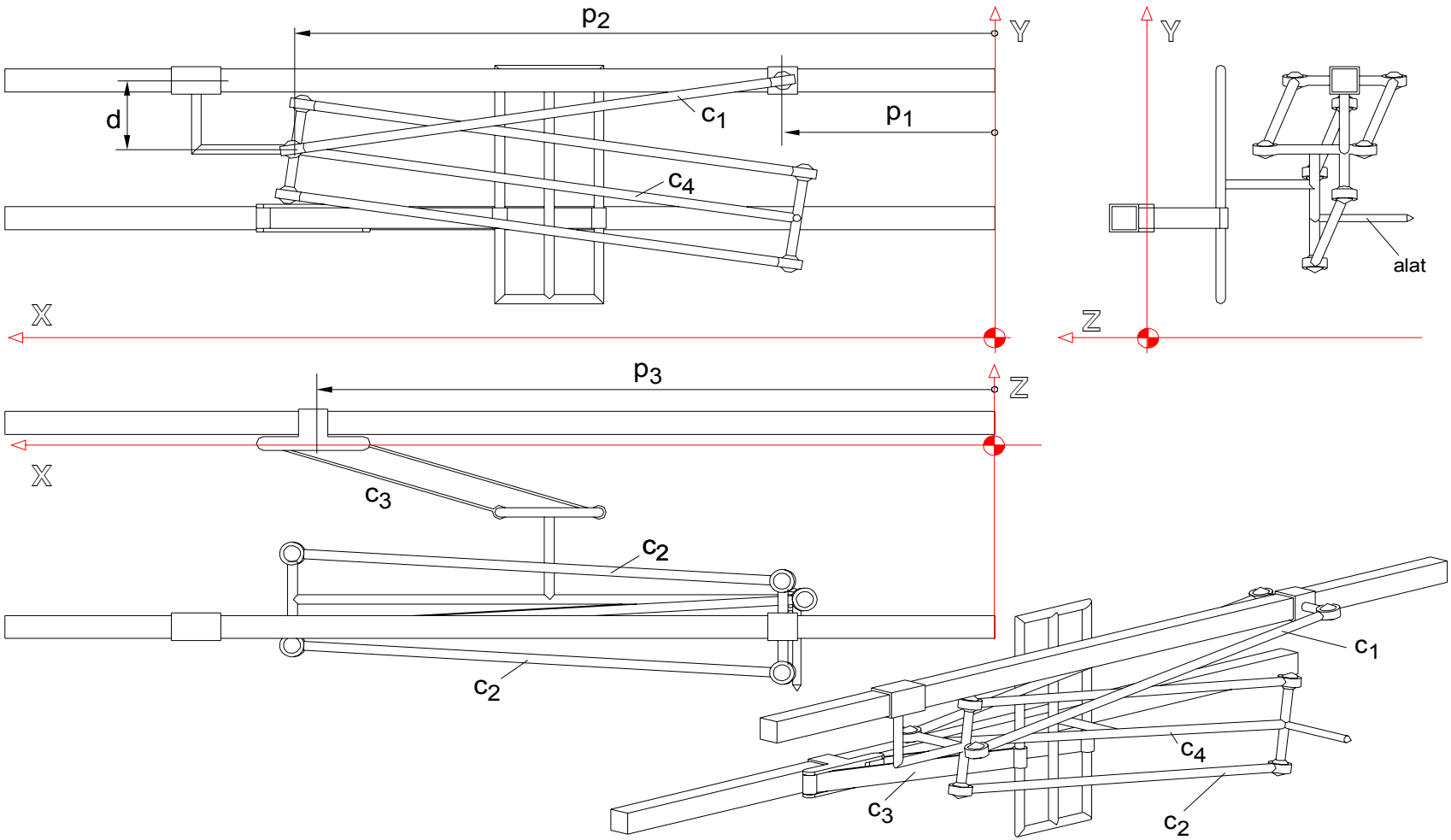
Dr Dragan Milutinović, Dr Miloš Glavonjić, Mr Saša Živanović

Sadržaj:

pn0102



Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom



	PROJEKTNI TIM	potpis	datum	16.11.2004.	
	dr Miloš Glavonjić				
	dr Dragan Milutinović				
	mr Saša Živanović				

Mašinski fakultet Beograd
KaProM

Naziv
pn 102
Troosna horizontalna glodalica
sa paralelnom kinematikom ("spojke gore")

Oznaka pn102 | Listova | List

Izvor pod. | Zamena za

Koordinate karakterističnih tačaka mehanizma pn102. Jedinice mere: dužine u mm.		
c1=1003.17 c2=1025.914 c3= 500 mm c4= 1029.561	zp2= 10 zp3=200 xp3=500 y01=600 z01=-400 y03=300	d=150 $\alpha = a\sin\left(\frac{d}{c_4}\right)$

Rešenja inverznog (IGP) i direktnog (DGP) geometrijskog problema

Rešenje IGP:

$$p_1 = x_p + c_4 \cdot \cos\alpha - \sqrt{c_1^2 - [(y_p - y_{01} + |d|)^2 + (z_p + z_{p2} - z_{01})^2]}$$

$$p_2 = x_p + \sqrt{c_2^2 - [(y_p - y_{01} - d)^2 + (z_p + z_{p2} - z_{01})^2]}$$

$$p_3 = x_p + x_{p3} + \sqrt{c_3^2 - (z_p + z_{p3})^2}$$

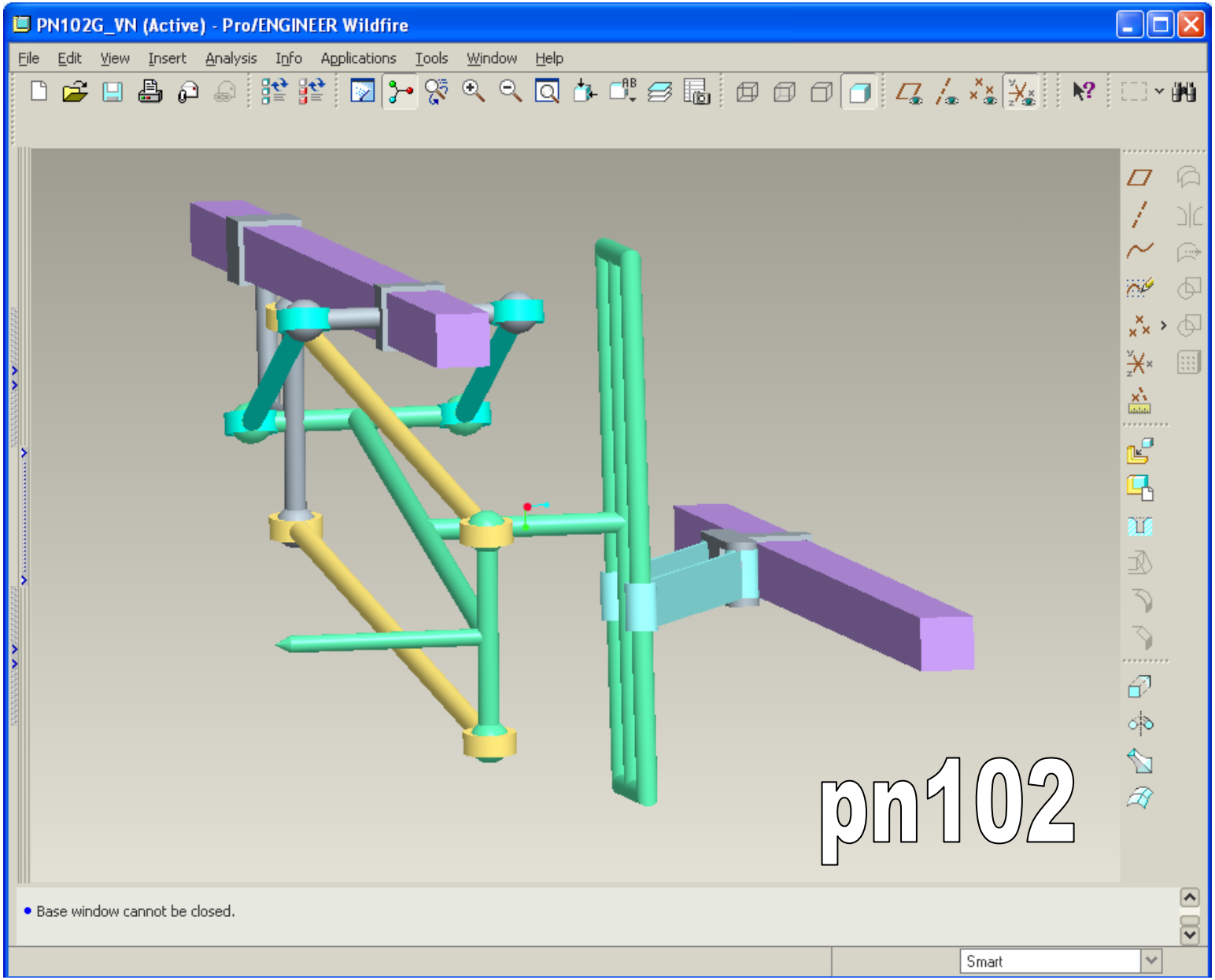
Rešenje DGP:

$$x_p = \frac{c_1^2 - c_2^2 + p_2^2 - (p_1 - c_4 \cdot \cos\alpha)^2}{2(p_2 - p_1 + c_4 \cos\alpha)}$$

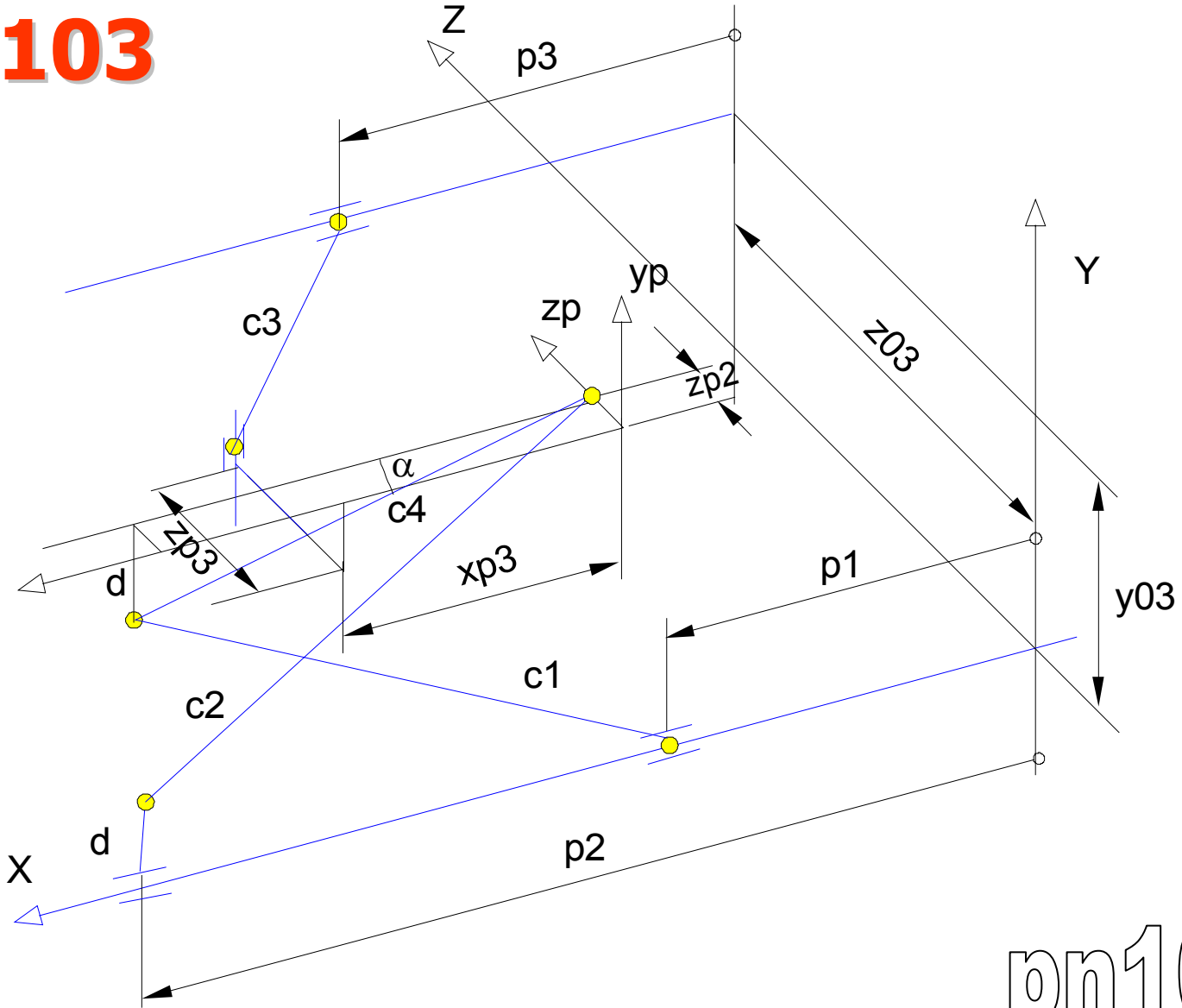
$$z_p = -z_{p3} - \sqrt{c_3^2 - (x_p - (p_3 - x_{p3}))^2}$$

$$y_p = y_{01} + d - \sqrt{c_2^2 - (x_p - p_2)^2 - (z_p + z_{p2} - z_{01})^2}$$

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom

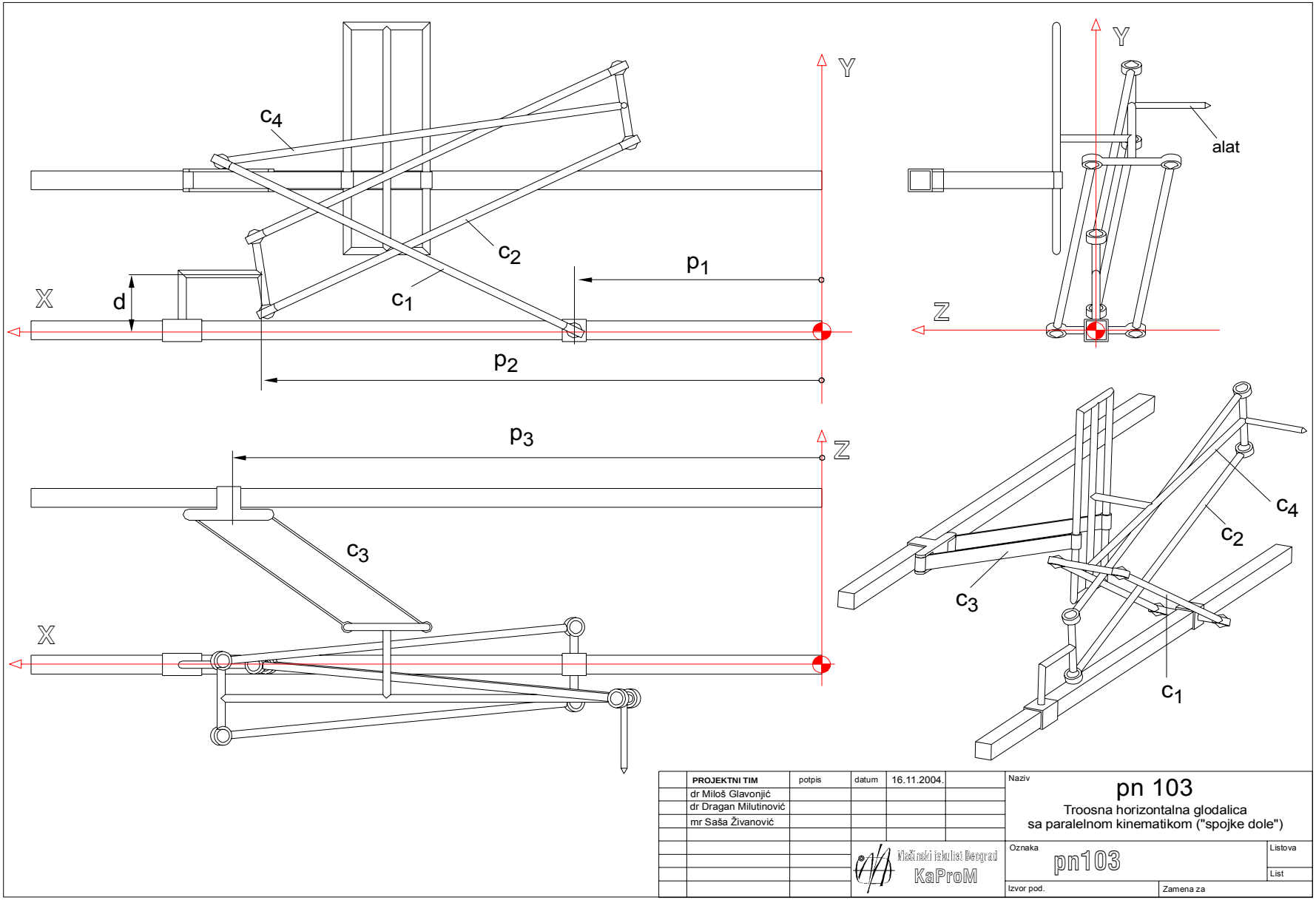


pn0103



pn103

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom



	PROJEKTNI TIM	potpis	datum	16.11.2004.	
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	dr Dragan Milutinović				
	mr Saša Živanović				

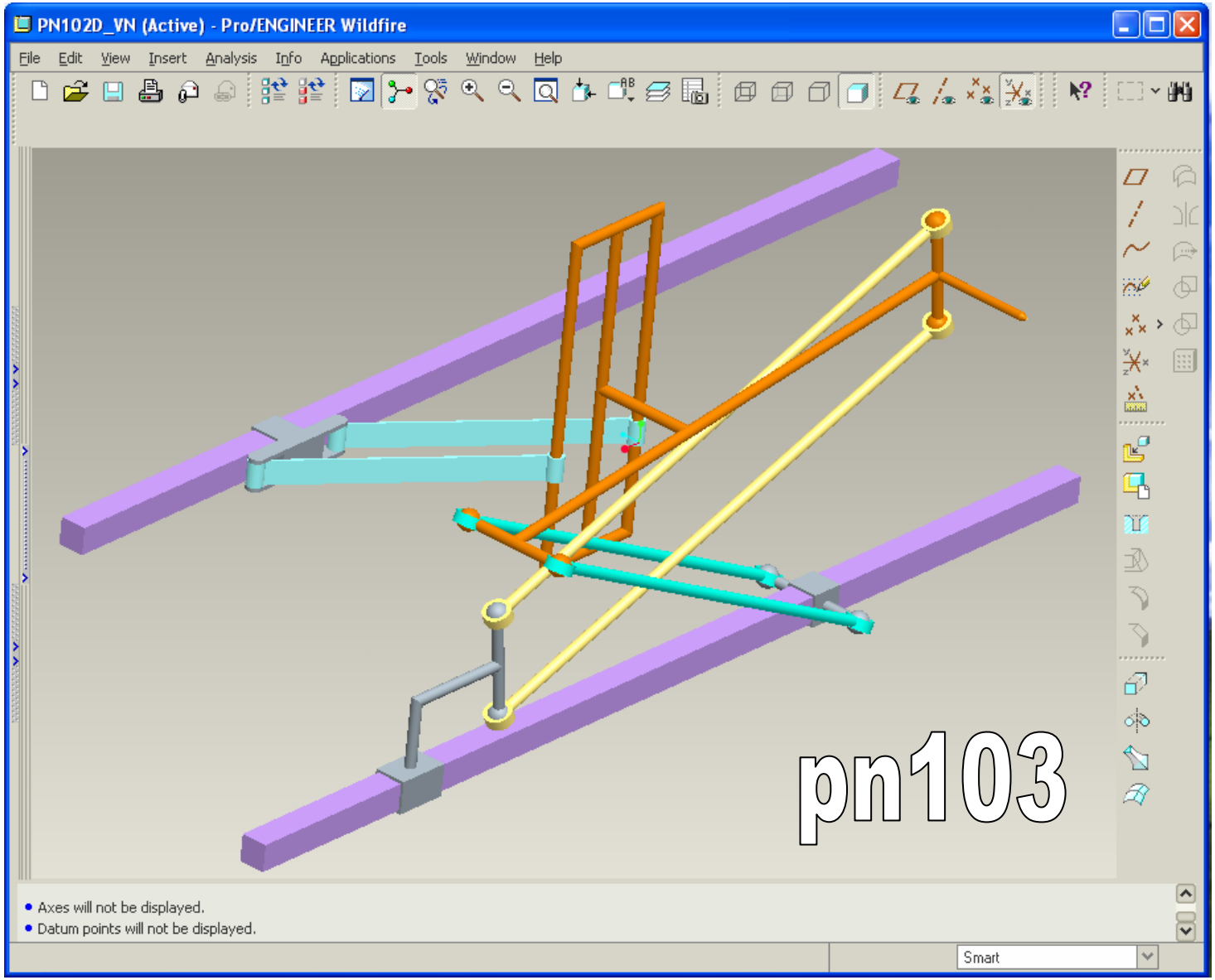
Mašinski fakultet Beograd
KaProM

Naziv: pn 103
Troosna horizontalna glodalica sa paralelnom kinematikom ("spojke dole")

Oznaka: pn103 | Listova | List

Izvor pod. | Zamena za

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom



Koordinate karakterističnih tačaka mehanizma pn103. Jedinice mere: dužine u mm.		
c1=1003.17 c2=1025.914 c3= 500 mm c4= 1029.561	zp2= 10 zp3=200 z03=400 xp3=600	d=150 $\alpha = a\sin\left(\frac{d}{c_4}\right)$

Rešenja inverznog (IGP) i direktnog (DGP) geometrijskog problema

Rešenje IGP:

$$p_1 = x_p + c_4 \cdot \cos\alpha - \sqrt{c_1^2 - [(y_p - d)^2 + (z_p + z_{p2})^2]}$$

$$p_2 = x_p + \sqrt{c_2^2 - [(y_p - d)^2 + (z_p + z_{p2})^2]}$$

$$p_3 = x_p + x_{p3} + \sqrt{c_3^2 - (z_p + z_{p3} - z_{03})^2}$$

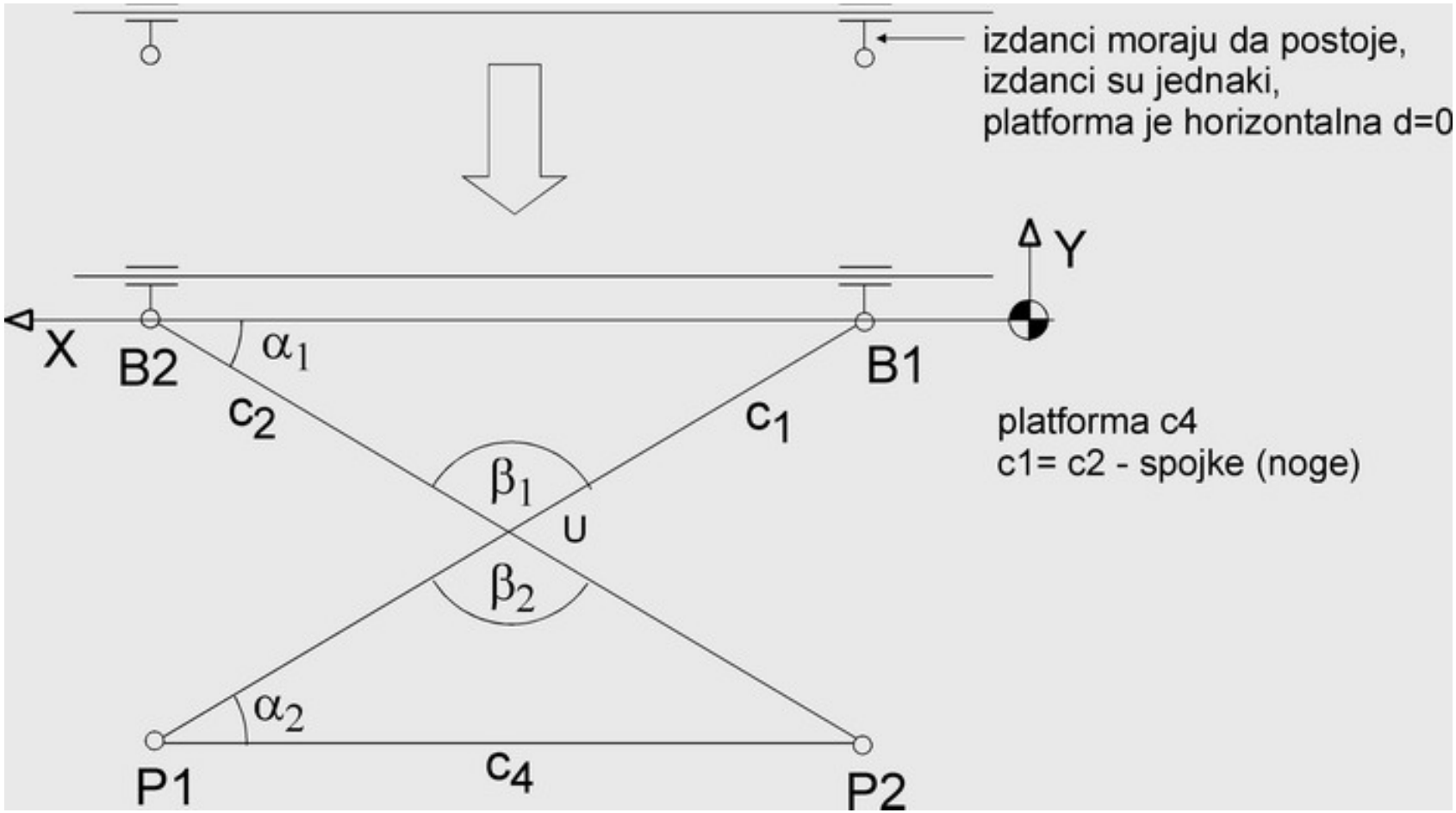
Rešenje DGP:

$$x_p = \frac{c_1^2 - c_2^2 + p_2^2 - (p_1 - c_4 \cdot \cos\alpha)^2}{2(p_2 - p_1 + c_4 \cos\alpha)}$$

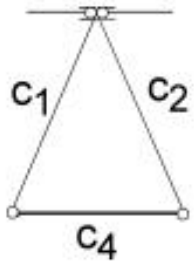
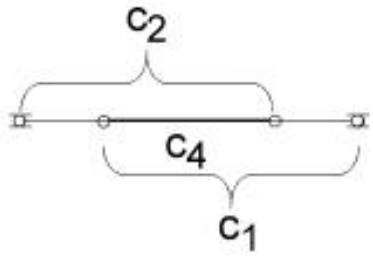
$$z_p = z_{03} - z_{p3} - \sqrt{c_3^2 - (x_p - (p_3 - x_p - x_{p3}))^2}$$

$$y_p = d + \sqrt{c_2^2 - (x_p - p_2)^2 - (z_p + z_{p2})^2}$$

VARIJANTE MEHANIZMA pn 102

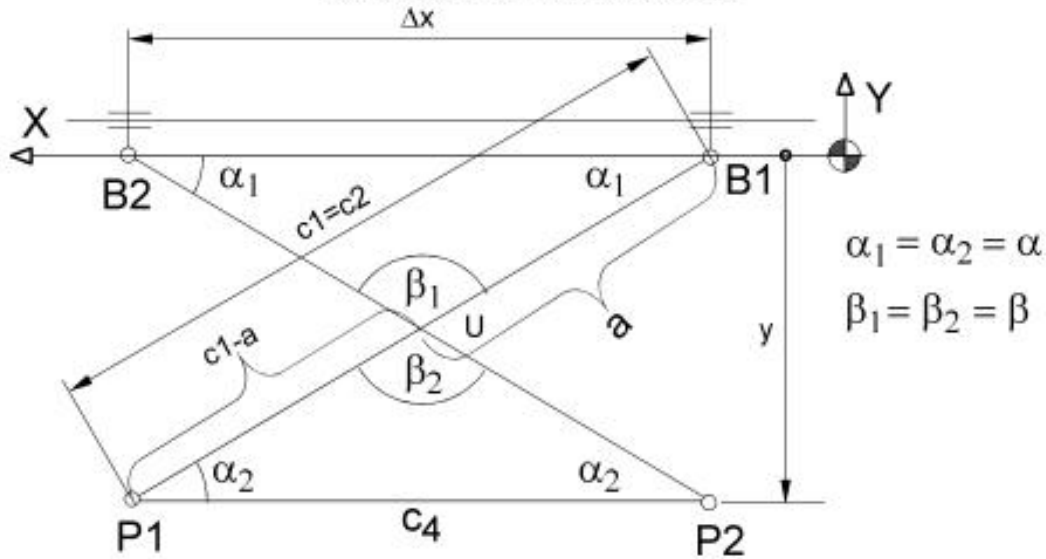


- **Granični slučajevi:**

Za varijantu ukrštenih spojki (neukrštene nisu razmatrane)		

- S obzirom da platforma osteje uvek paralelna sama sebi tj. X osi trouglovi B1B2U i P1P2U su uvek jednakokraki i ispada da su skoro uvek slični (osim u graničnim slučajevima).

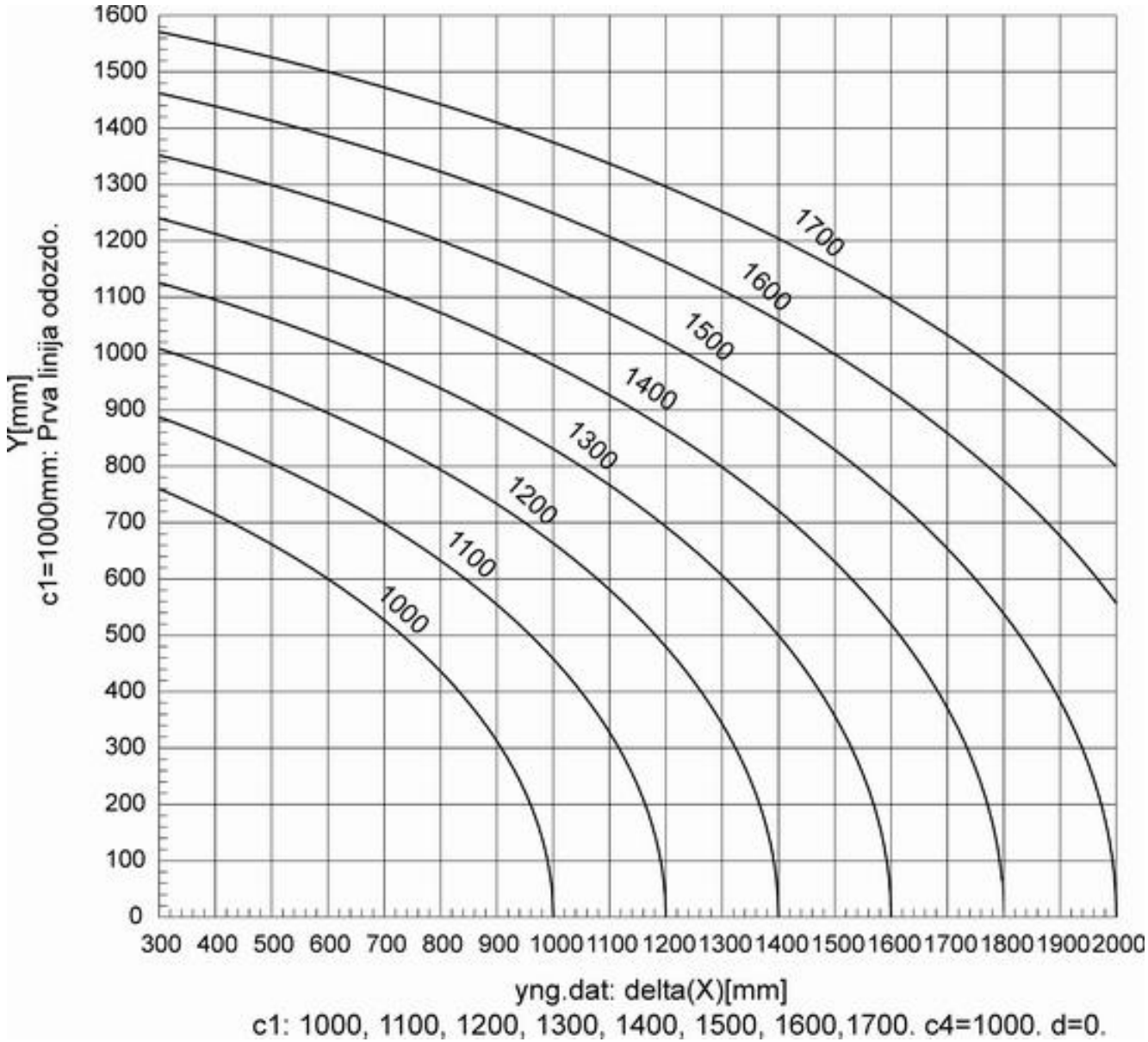
$\beta_1 = \beta_2$ (unakrsni uglovi) i $\alpha_1 = \alpha_2$ (uglovi sa paralelnim kracima) $\Rightarrow$ trouglovi B1B2U i P1P2U su slični.

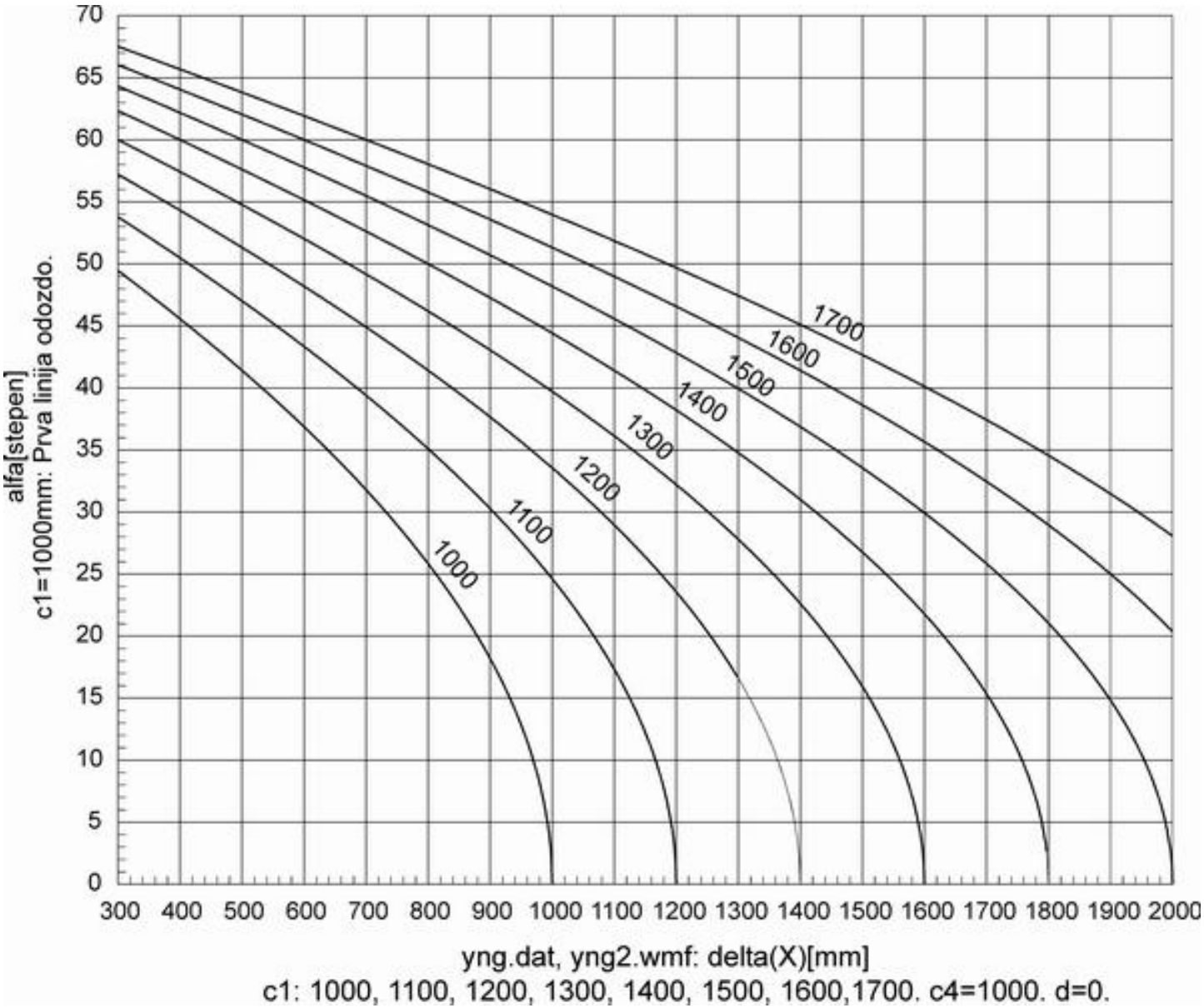


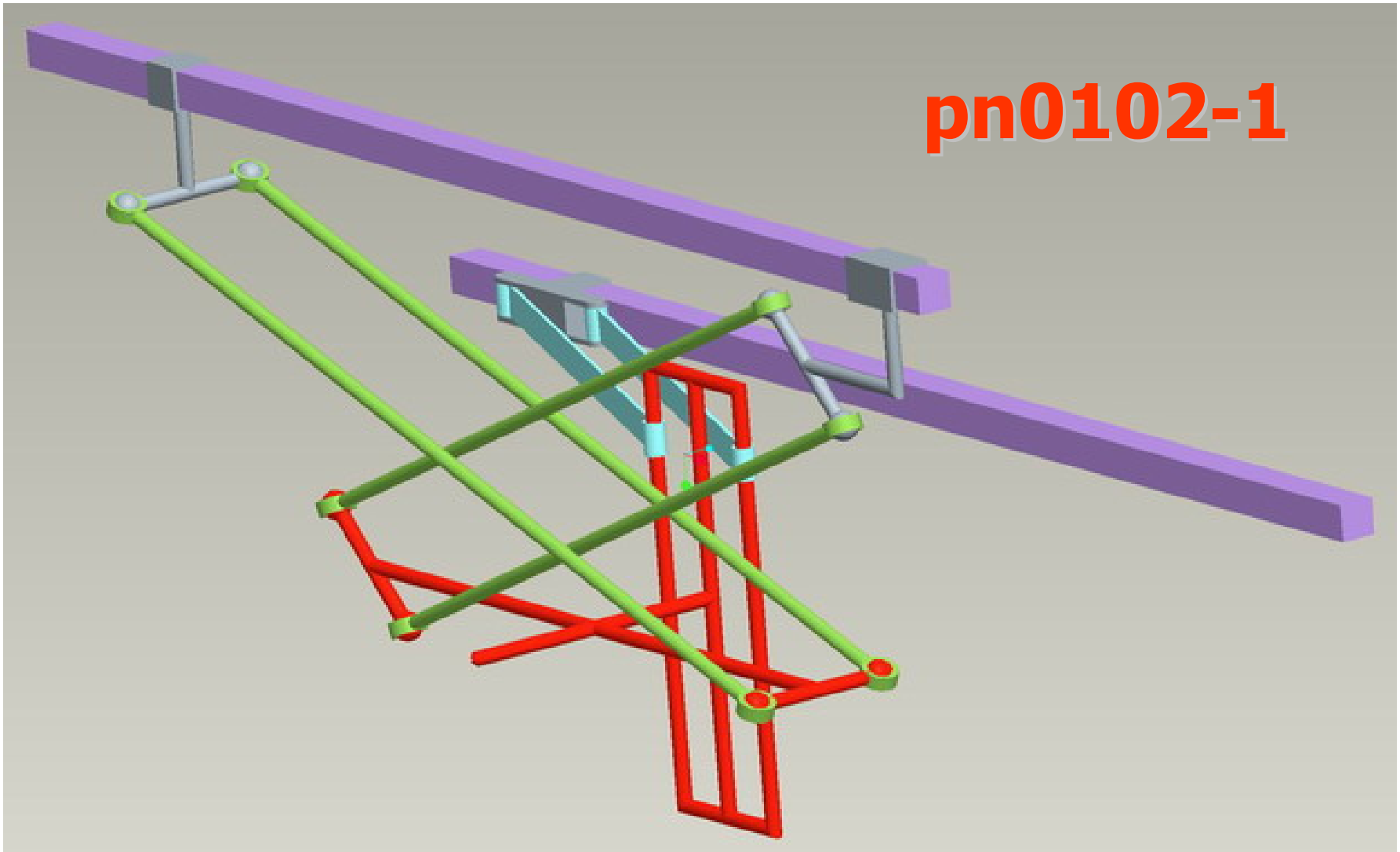
Treba odrediti c_4, Δx, $c_1 = c_2 = c$ tako da se dobije željeno kretanje od Y= 800 mm, odnosno da je Ymax – Ymin = 800 mm.

Prema preeliminarnoj analizi sa prethodne strane odnosno na osnovu sličnosti trouglova mogu se postaviti sledeće jednačine:

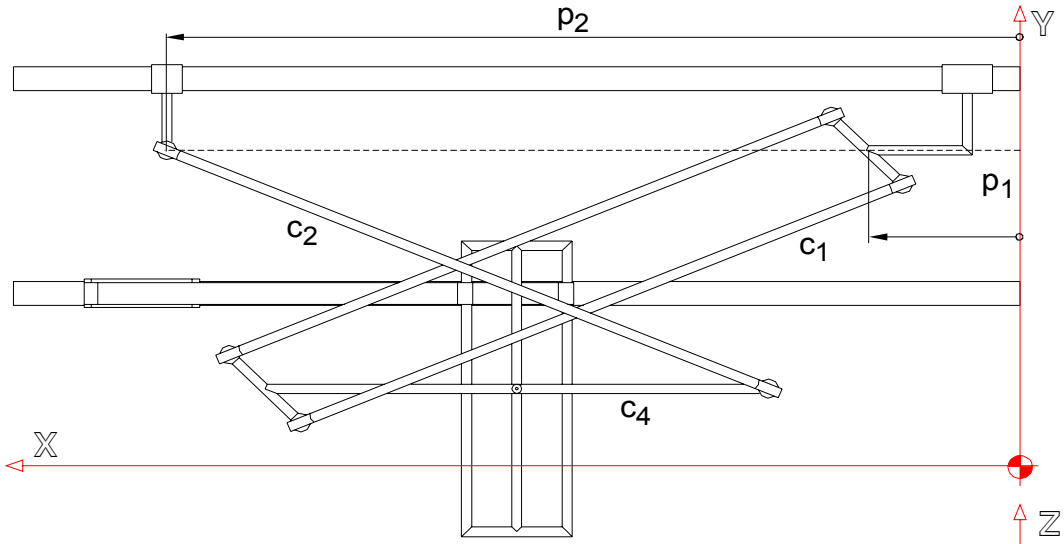
$\frac{\Delta x}{c_4} = \frac{a}{c_1 - a}$ $c_4 a = \Delta x c_1 - \Delta x a$ $a(c_4 + \Delta x) = \Delta x c_1$ $a = \frac{\Delta x \cdot c_1}{c_4 + \Delta x}$	$\cos\alpha = \frac{\Delta x}{2a}$ $\alpha = a\cos\left(\frac{\Delta x}{2a}\right)$ $\beta = 180 - 2\alpha$ $y = c_1 \cdot \sin\alpha$

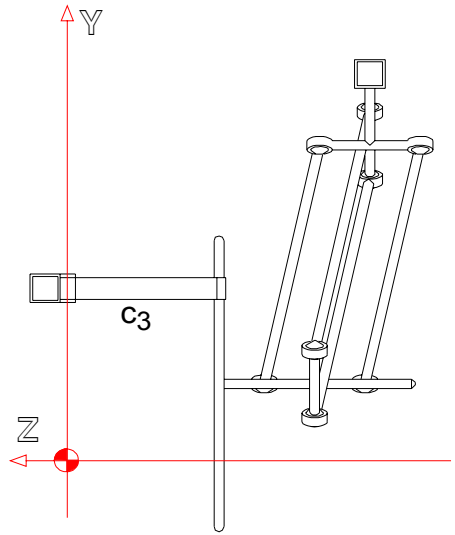

Y[mm]
c1=1000mm: Prva linija odozdo.
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
1700
1600
1500
1400
1300
1200
1100
1000
300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
yng.dat: delta(X)[mm]
c1: 1000, 1100, 1200, 1300, 1400, 1500, 1600,1700. c4=1000. d=0.

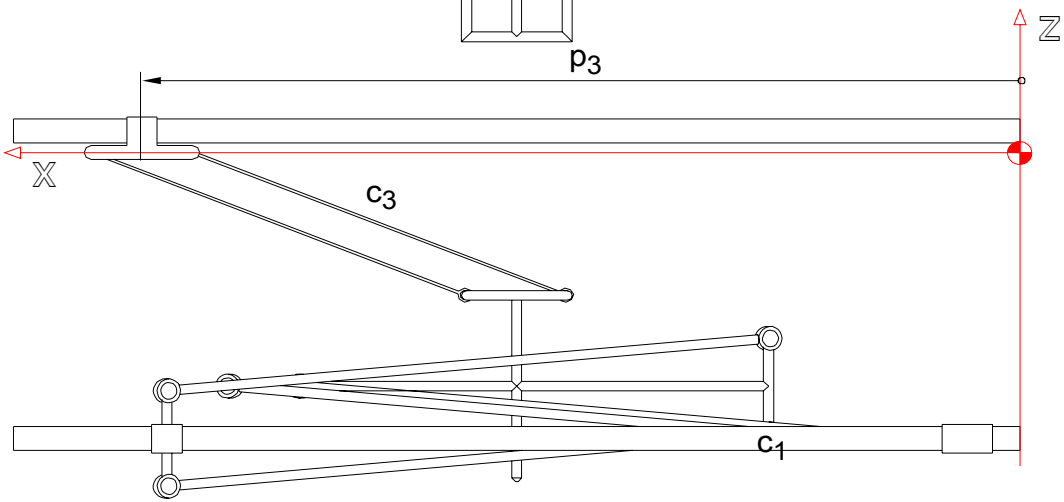

alfa[stepen]
c1=1000mm: Prva linija odozdo.
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
1700
1600
1500
1400
1300
1200
1100
1000
yng.dat, yng2.wmf: delta(X)[mm]
c1: 1000, 1100, 1200, 1300, 1400, 1500, 1600,1700. c4=1000. d=0.

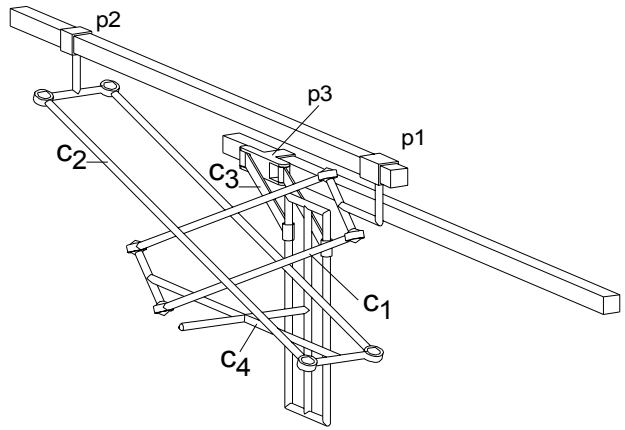

pn0102-1

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom









	PROJEKTNI TIM	potpis	datum	17.11.2004.	Naziv: pn 102-1 — Troosna horizontalna glodalica sa paralelnom kinematikom ("spojke gore")
	dr Miloš Glavonjić				
	dr Dragan Milutinović				
	mr Saša Živanović				
	Mašinski fakultet Beograd KaProM				Oznaka: pn102 -1 — Listova / List
					Izvor pod. — Zamena za

Koordinate karakterističnih tačaka mehanizma pn102-1. Jedinice mere: dužine u mm.		
c1=1300 c2=1300 c3= **800** c4= 1000	zp2= 10 zp3=200 xp3=500 y01=600 z01=**-600** y03=300	d=0 $\alpha = 0$

Rešenja inverznog (IGP) i direktnog (DGP) geometrijskog problema

Rešenje IGP:

$$p_1 = x_p + c_4 - \sqrt{c_1^2 - [(y_p - y_{01})^2 + (z_p + z_{p2} - z_{01})^2]}$$

$$p_2 = x_p + \sqrt{c_2^2 - [(y_p - y_{01})^2 + (z_p + z_{p2} - z_{01})^2]}$$

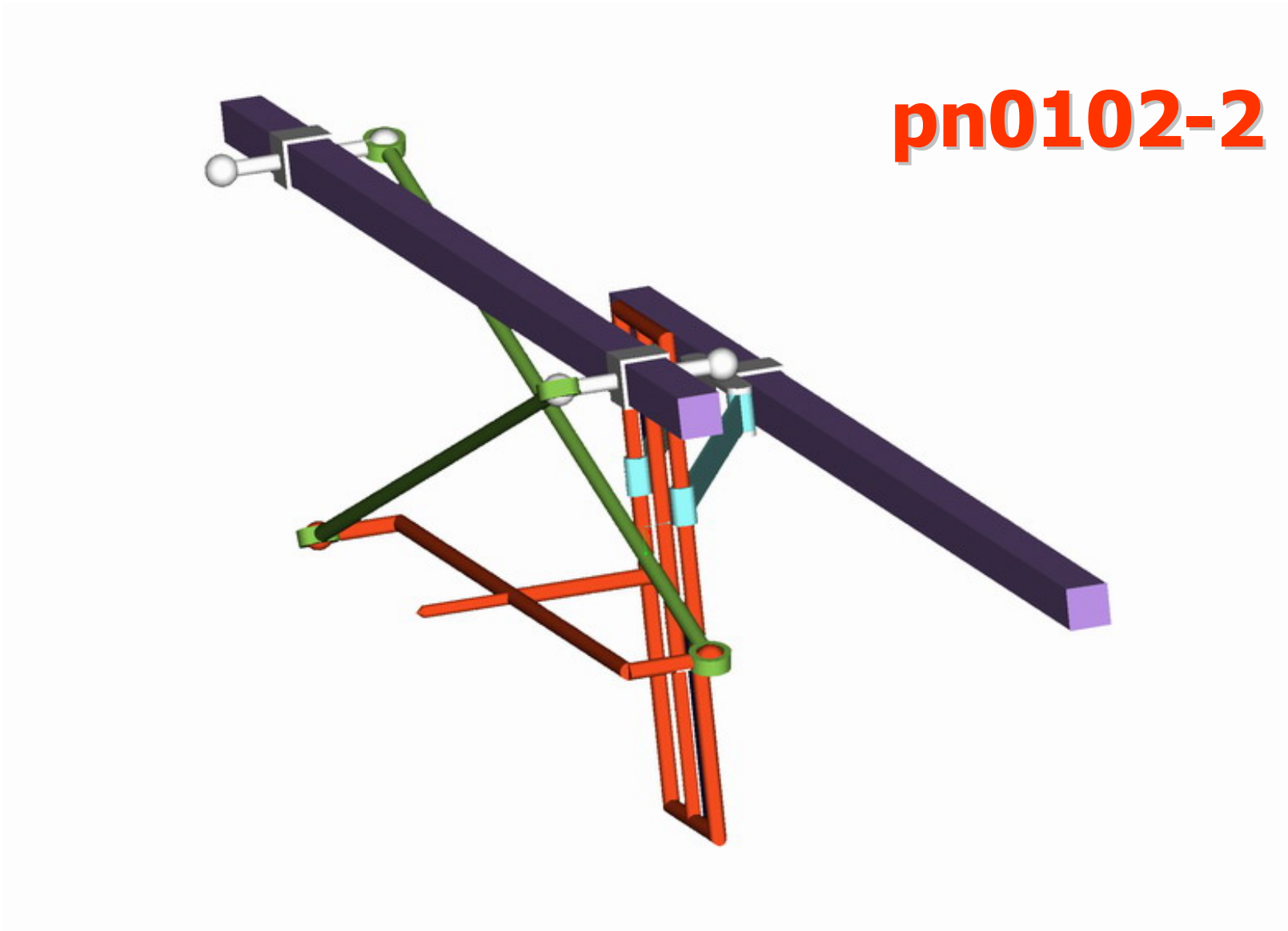
$$p_3 = x_p + x_{p3} + \sqrt{c_3^2 - (z_p + z_{p3})^2}$$

Rešenje DGP:

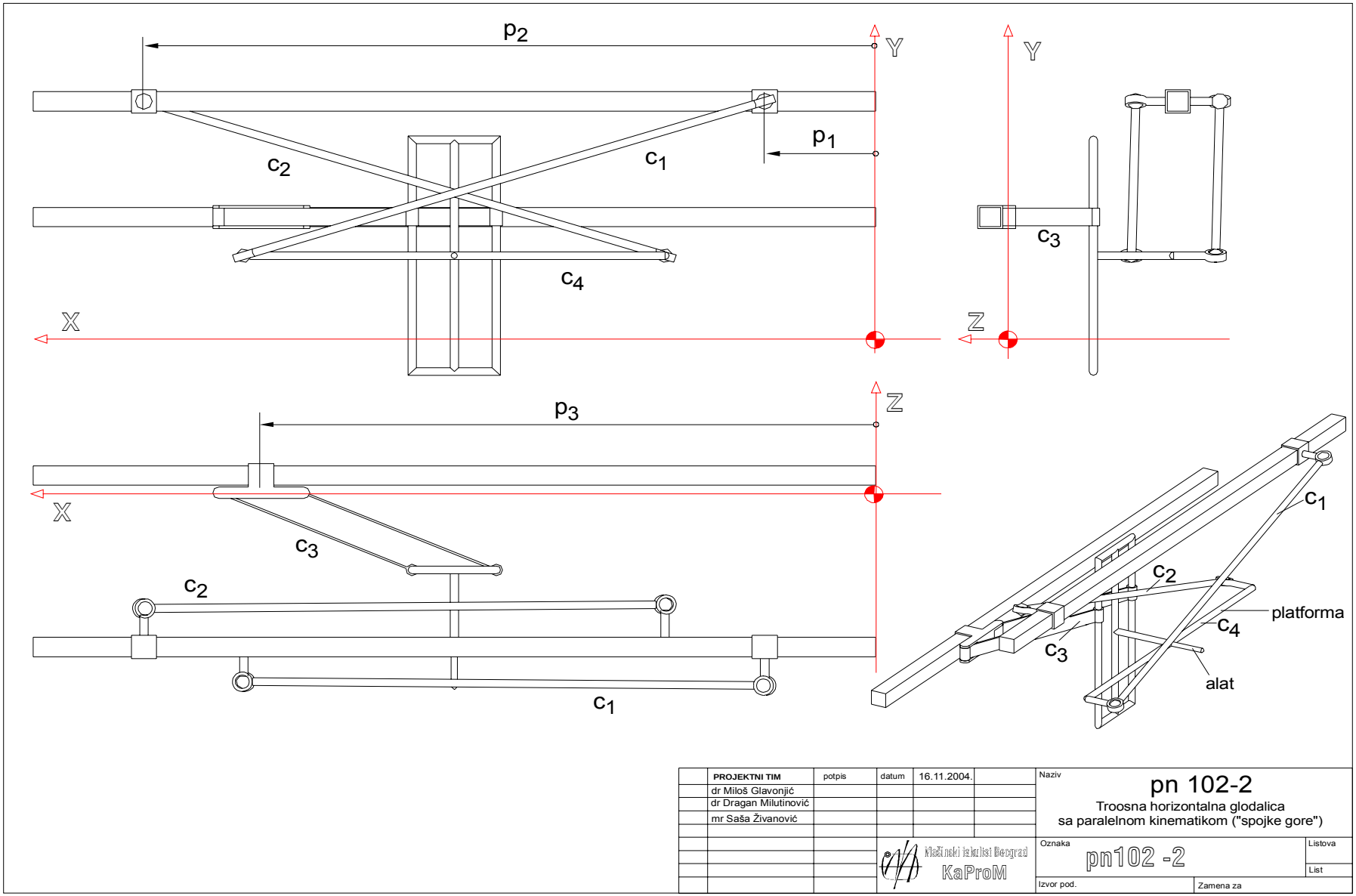
$$x_p = \frac{c_1^2 - c_2^2 + p_2^2 - (p_1 - c_4)^2}{2(p_2 - p_1 + c_4)}$$

$$z_p = -z_{p3} - \sqrt{c_3^2 - (x_p - (p_3 - x_{p3}))^2}$$

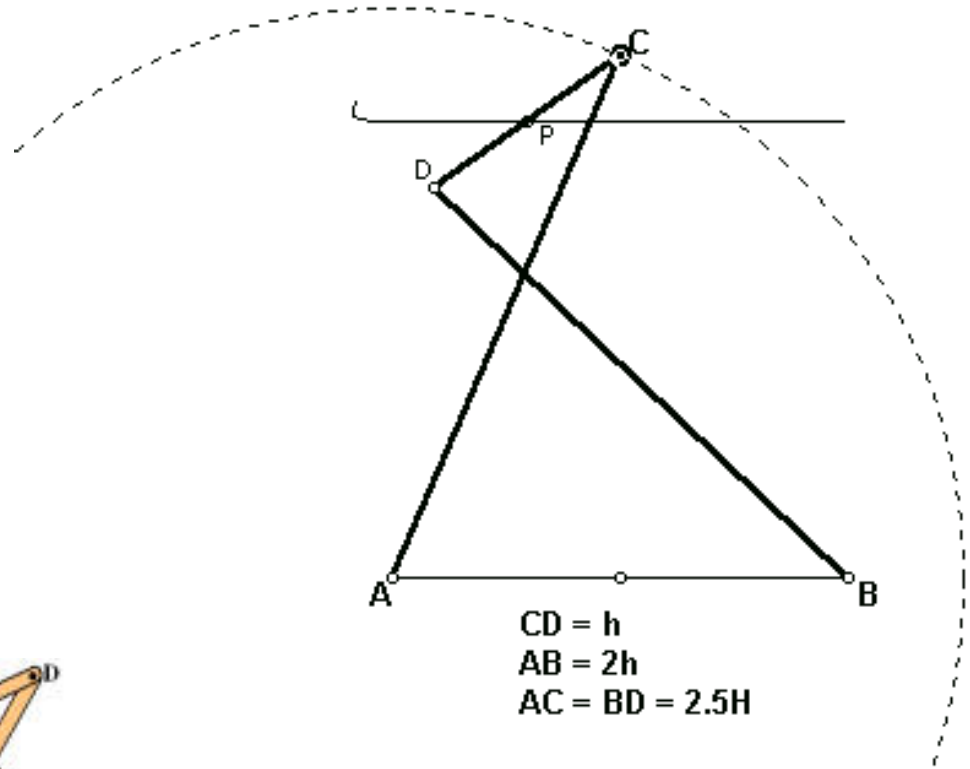
$$y_p = y_{01} - \sqrt{c_2^2 - (x_p - p_2)^2 - (z_p + z_{p2} - z_{01})^2}$$

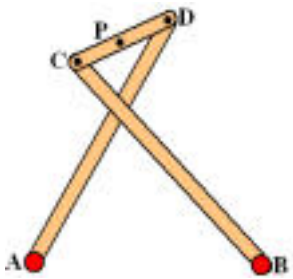

pn0102-2

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom

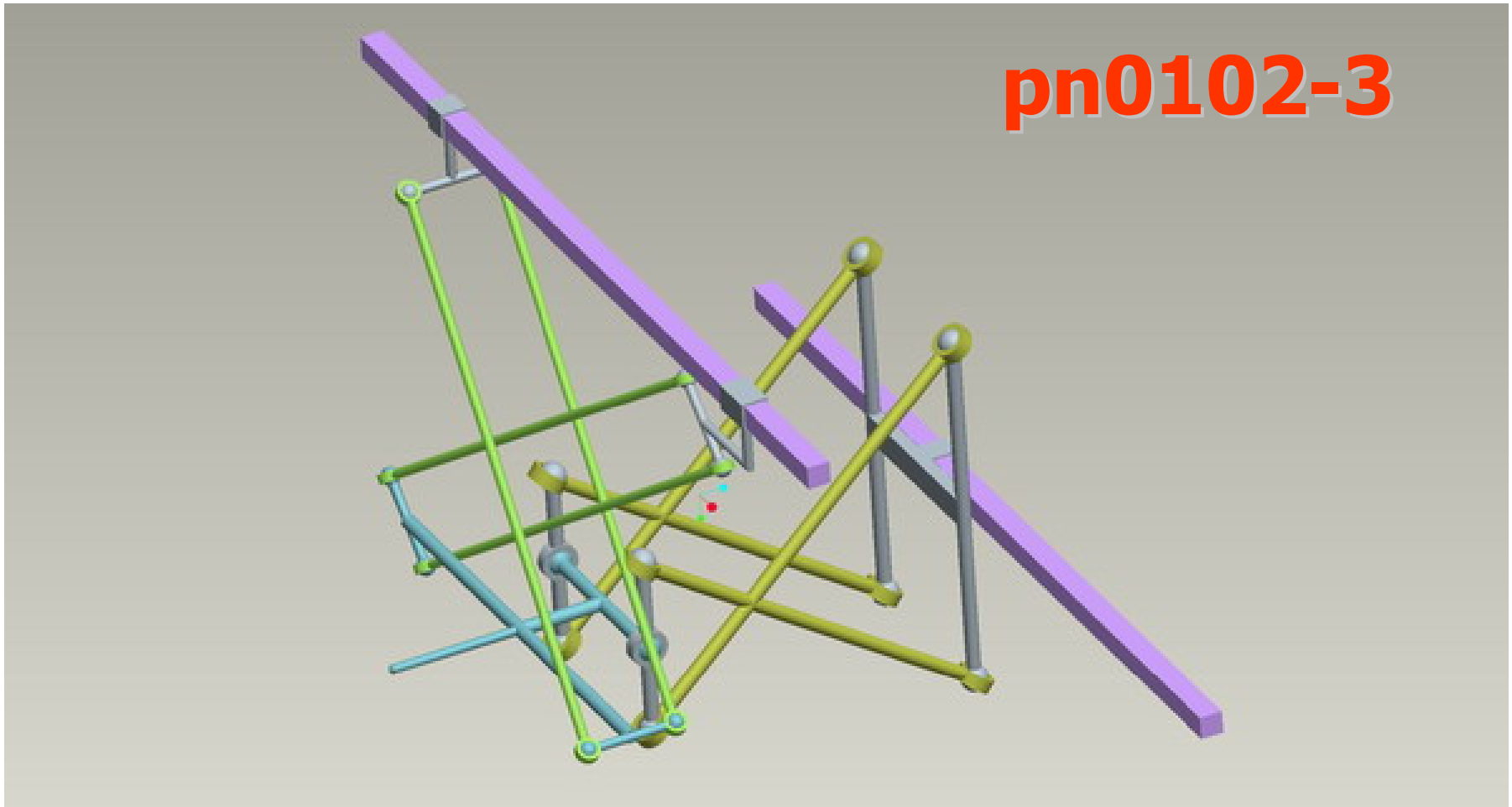


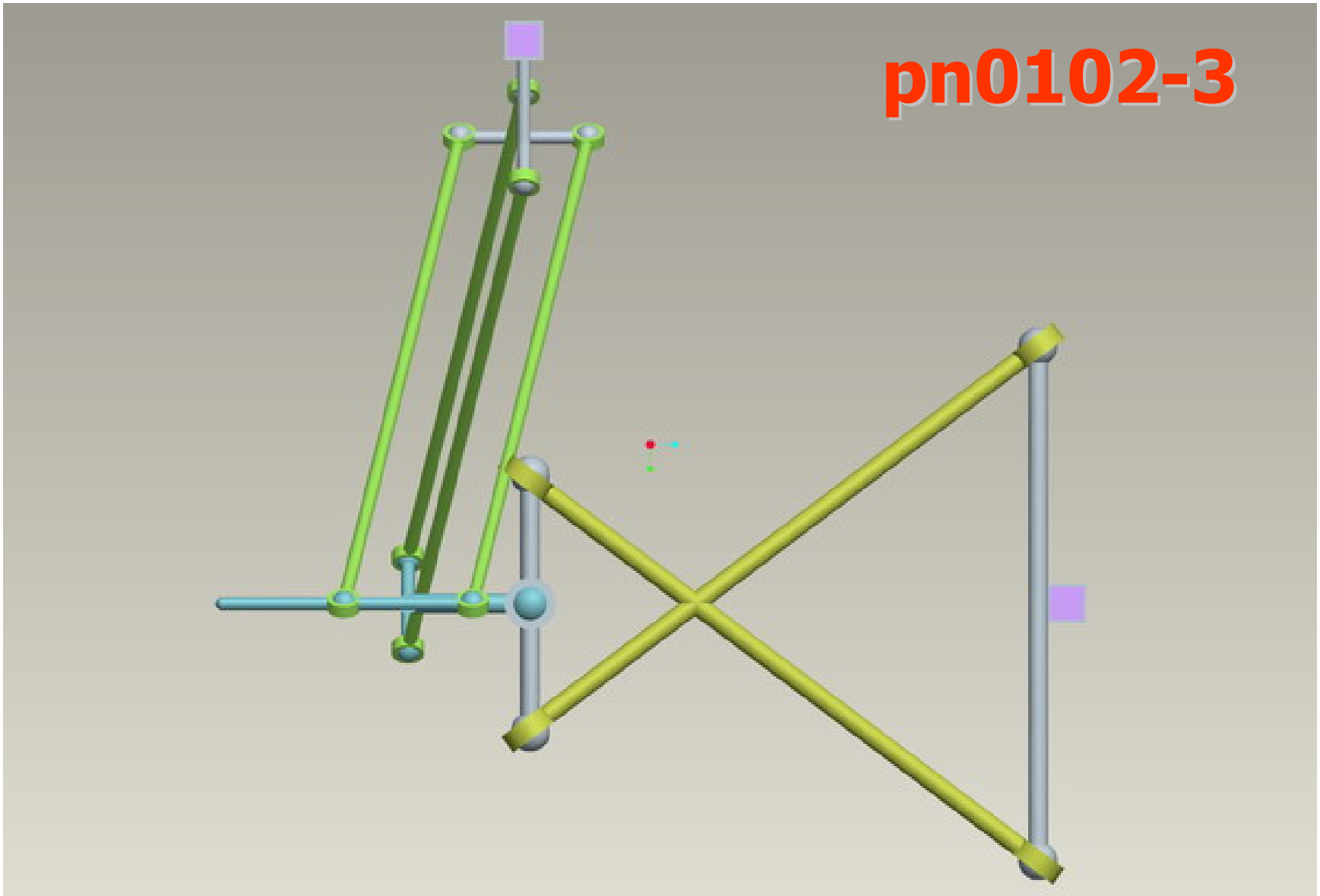
PROJEKTNI TIM	potpis	datum	16.11.2004.	Naziv	pn 102-2
dr Miloš Glavonjić					Troosna horizontalna glodalica sa paralelnom kinematikom ("spojke gore")
dr Dragan Milutinović					
mr Saša Živanović					
Mašinski fakultet Beograd KaProM				Oznaka	pn102 -2
				Listova	
				List	
				Izvor pod.	Zamena za



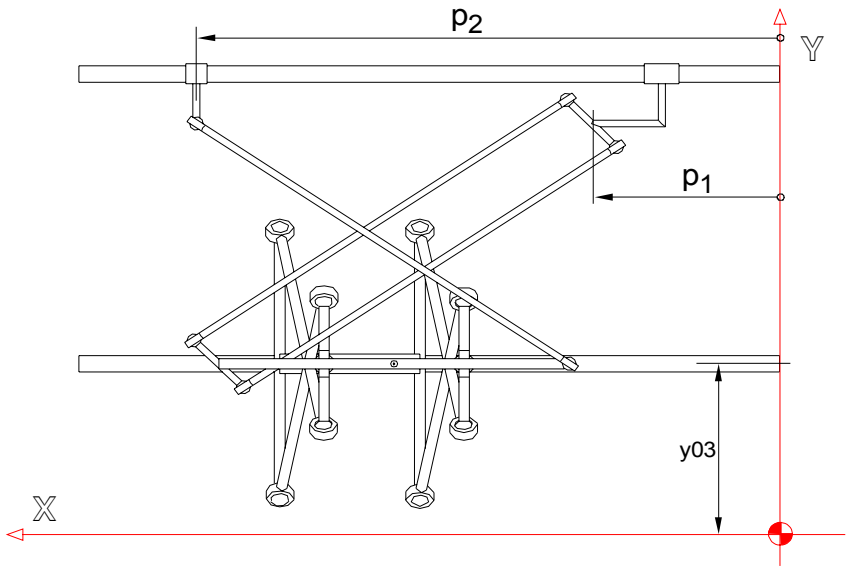


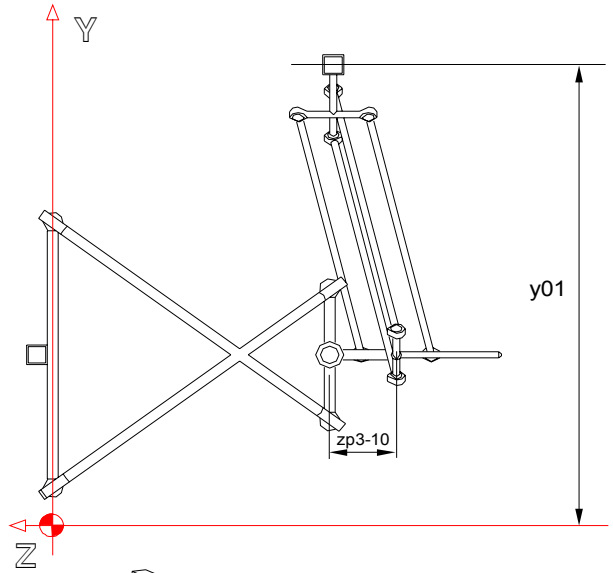
Chebyshev mehanizam

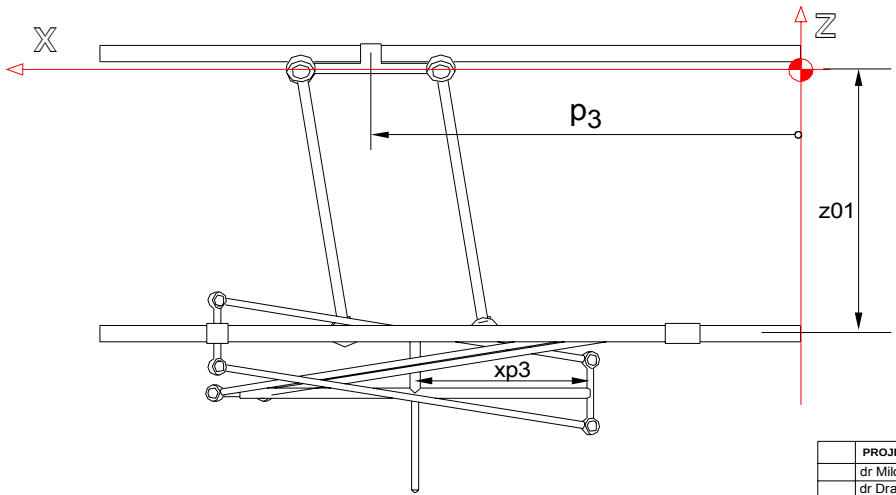

pn0102-3

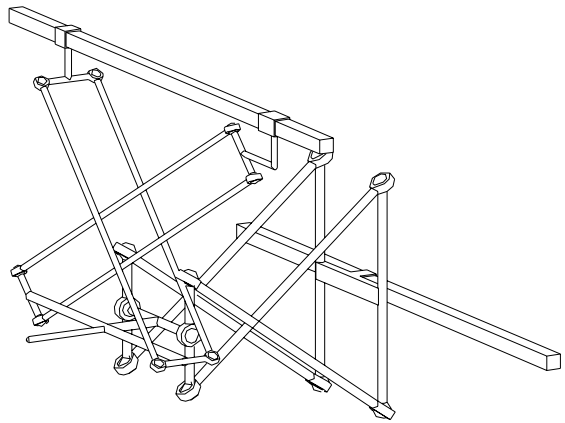

pn0102-3

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom









	PROJEKTNI TIM	potpis	datum	18.11.2004.		
	dr Miloš Glavonjić					
	dr Dragan Milutinović					
	mr Saša Živanović					

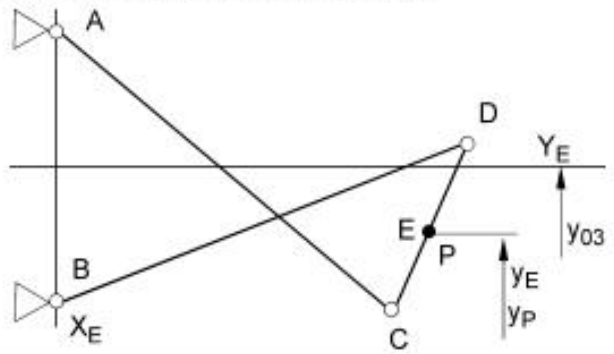
Mašinski fakultet Beograd
KaProM

Naziv: **pn 102-3**
Troosna horizontalna glodalica sa paralelnom kinematikom ("pasivni zglob - "Chebychev")

Oznaka: pn102 -3 | Listova / List

Izvor pod. | Zamena za

Koordinate karakterističnih tačaka mehanizma pn102-3. Jedinice mere: dužine u mm.

c1=1300 c2=1300 **c3= 800** c4= 1000 d=0, $\alpha = 0$ **c=200**	$\overline{AB} = 4c$ $\overline{AC} = \overline{BD} = 5c$ $\overline{CE} = ED = c$	zp2= 10 zp3=200 xp3=500 **y01=1425** **z01=-800** **y03=700**	

Rešenja inverznog (IGP) [i direktnog (DGP)] **geometrijskog problema**

Račun za c3:

$$s_1 = 21c^2 + 8cx_E - 4x_E^2$$
$$s_2 = -2x_E - 4c$$
$$s_3 = -8.5c^2 - 0.5s_1 - 2x_E^2$$
$$s_{11} = 2(s_2 - 4c + 2x_E)$$
$$s_{12} = s_2^2 - 2s_3 + 5c^2 + s_1 + 16cx_E$$
$$s_{13} = -2s_2 s_3 + 84c^3 - 84c^2 x_E + 4cs_1$$

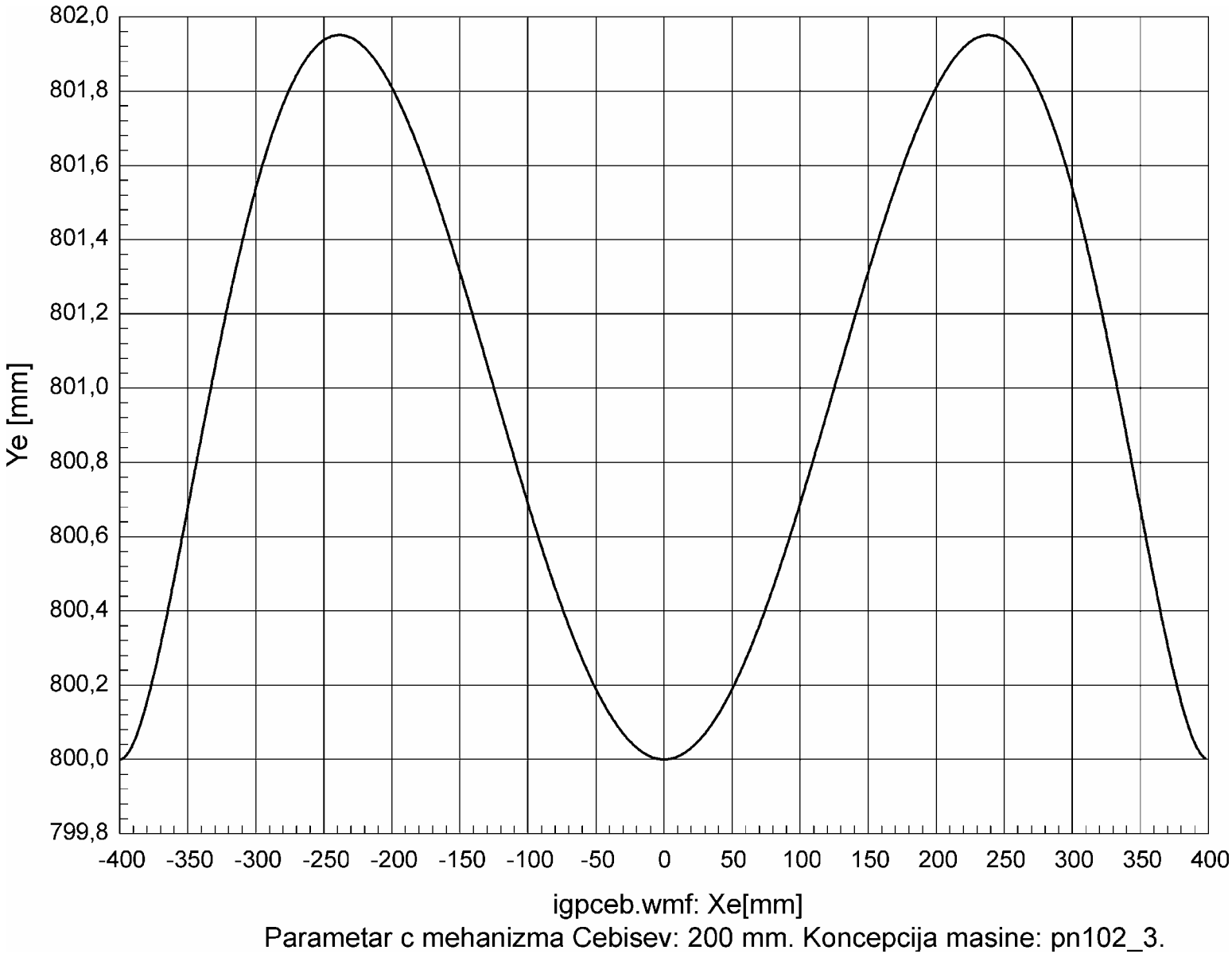
$$s_{14} = s_3^2 - 21c^2 s_1$$
$$s_{21} = s_{12}/s_{11}$$
$$s_{22} = s_{13}/s_{11}$$
$$p = (3s_{22} - s_{21}^2)/3$$
$$q = \frac{(27 + s_{23} + 2s_{21}^3 - 9s_{21}s_{22}}{27}$$
$$\varphi = \arccos(3q/(2p\sqrt{-p/3}))$$

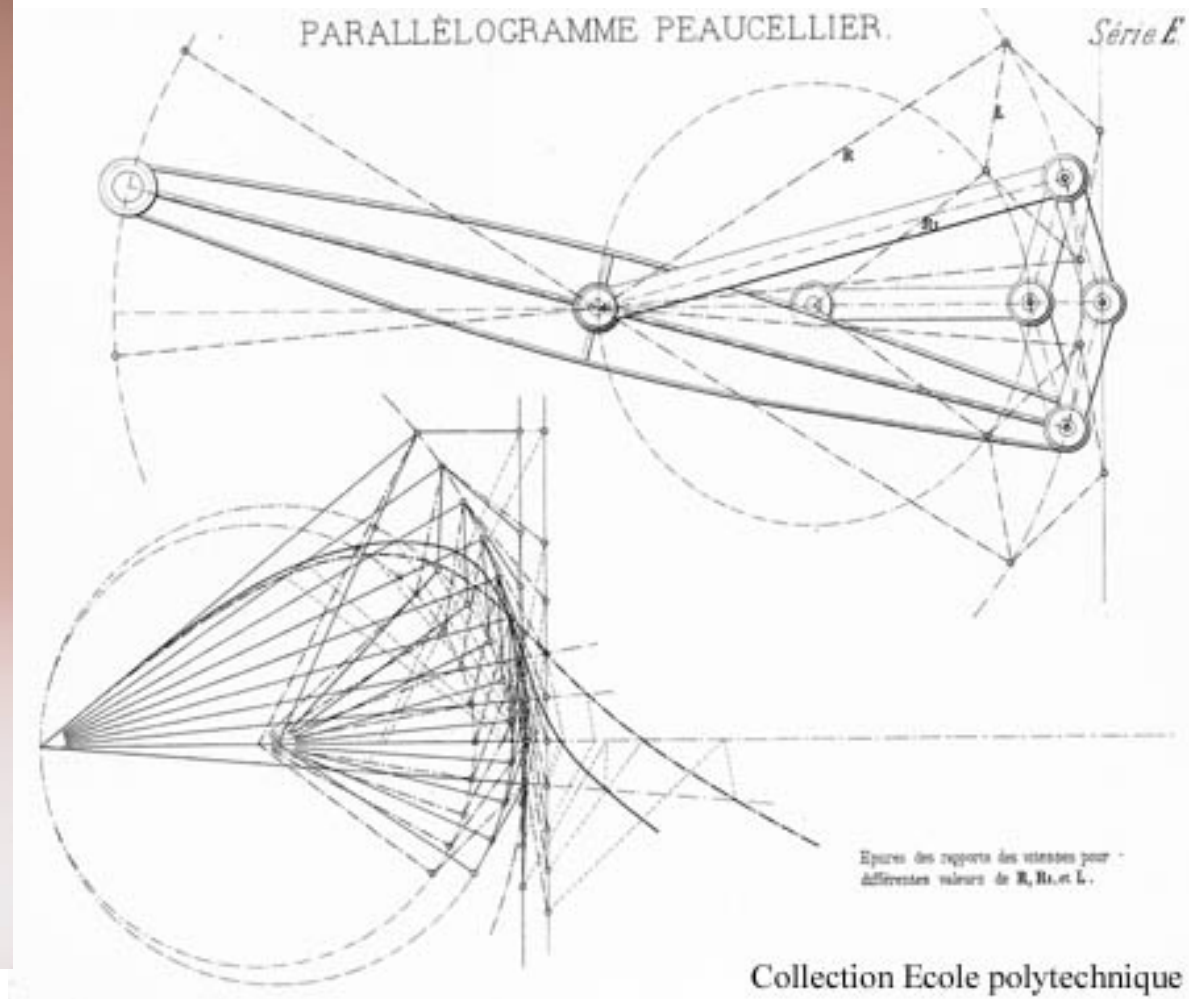
$$x_c = 2\sqrt{-p/3}\cos((\varphi + 4\pi)/3) - s_{21}/3$$
$$y_c = \sqrt{21c^2 - x_c^2 - 4cx_c}$$
$$x_d = 2x_E - x_c$$
$$y_d = \sqrt{s_1 - x_c^2 - (4c - 4x_E)x_c}$$
$$c_3 = (y_c + y_d)/2$$

Rešenje IGP:

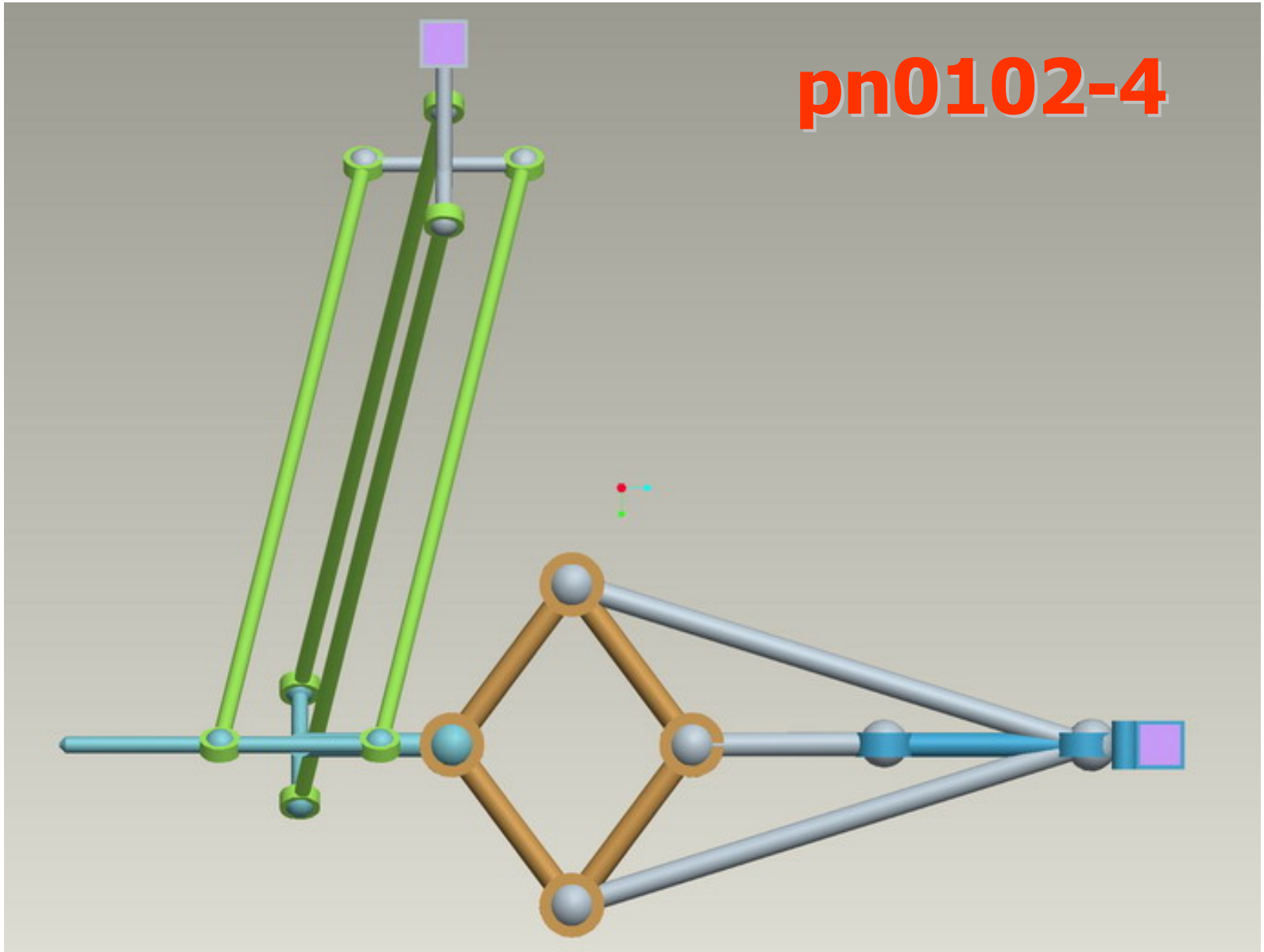
$$p_1 = x_p + c_4 - \sqrt{c_1^2 - [(y_p - y_{01})^2 + (z_p + z_{p2} - z_{01})^2]}$$
$$p_2 = x_p + \sqrt{c_2^2 - [(y_p - y_{01})^2 + (z_p + z_{p2} - z_{01})^2]}$$
$$p_3 = x_p + x_{p3} + \sqrt{c_3^2 - (z_p + z_{p3})^2}$$

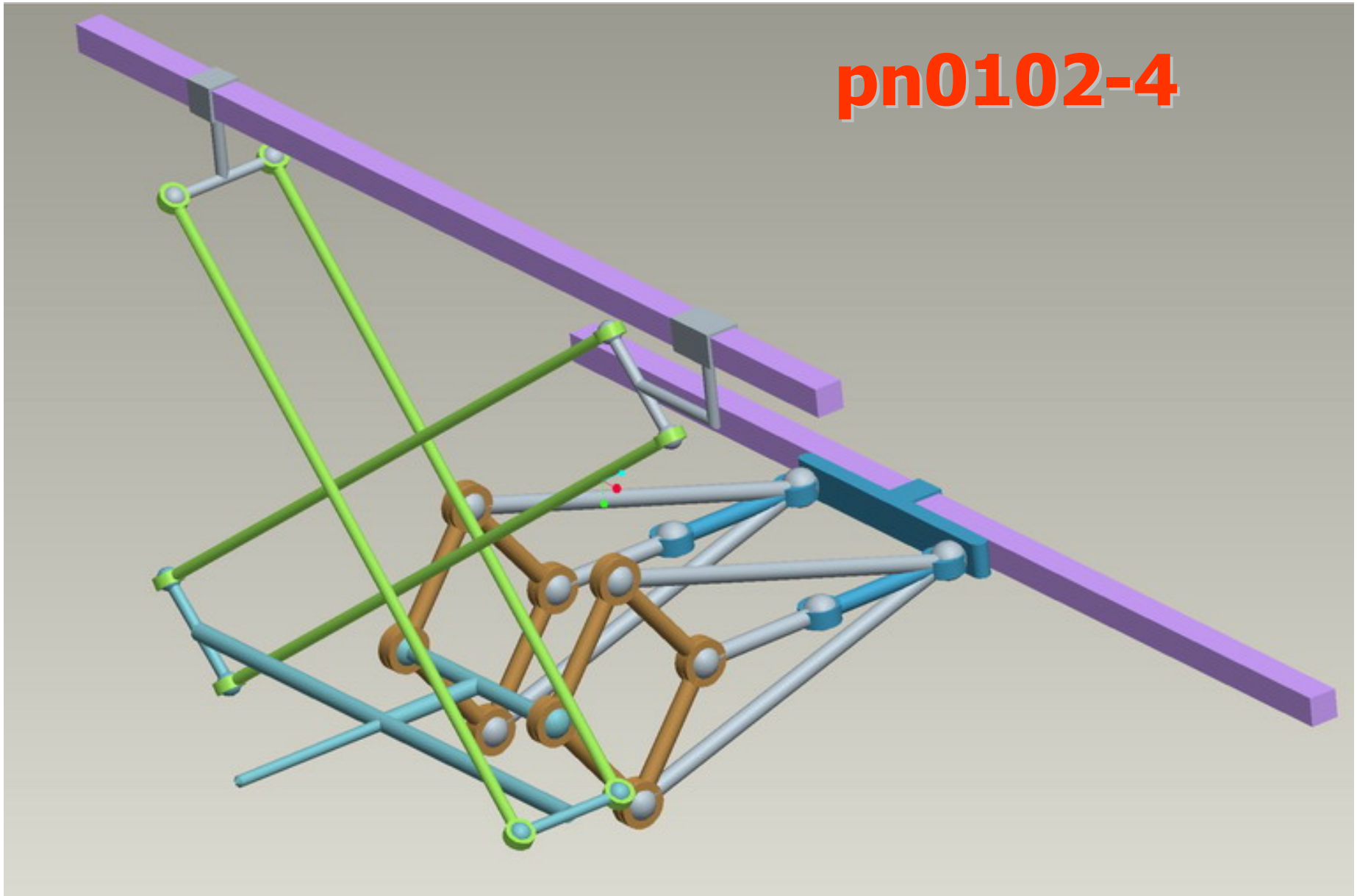
Rešenje DGP:


802,0
801,8
801,6
801,4
801,2
801,0
800,8
800,6
800,4
800,2
800,0
799,8
Ye [mm]
-400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400
igpceb.wmf: Xe[mm]
Parametar c mehanizma Cebisev: 200 mm. Koncepcija masine: pn102_3.

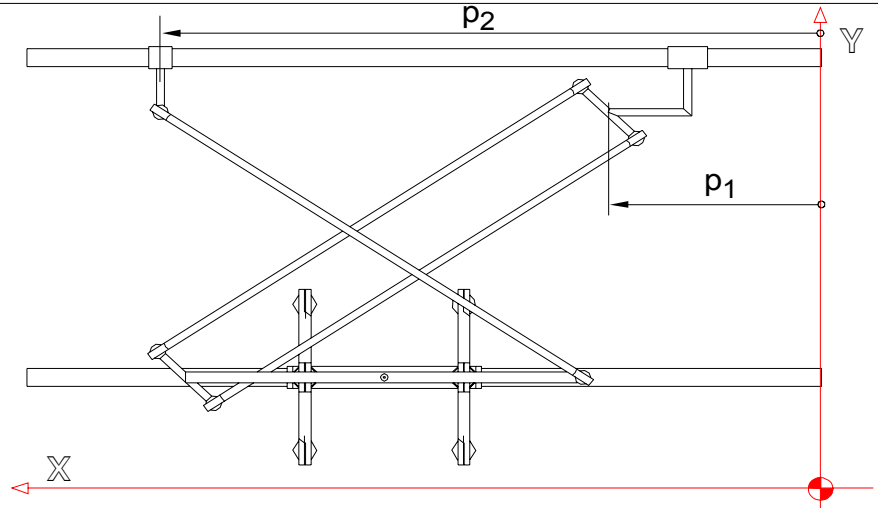


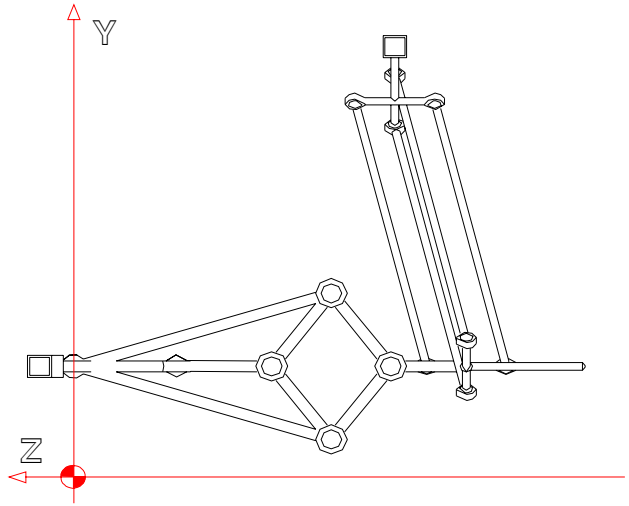
Peaucellier mehanizam

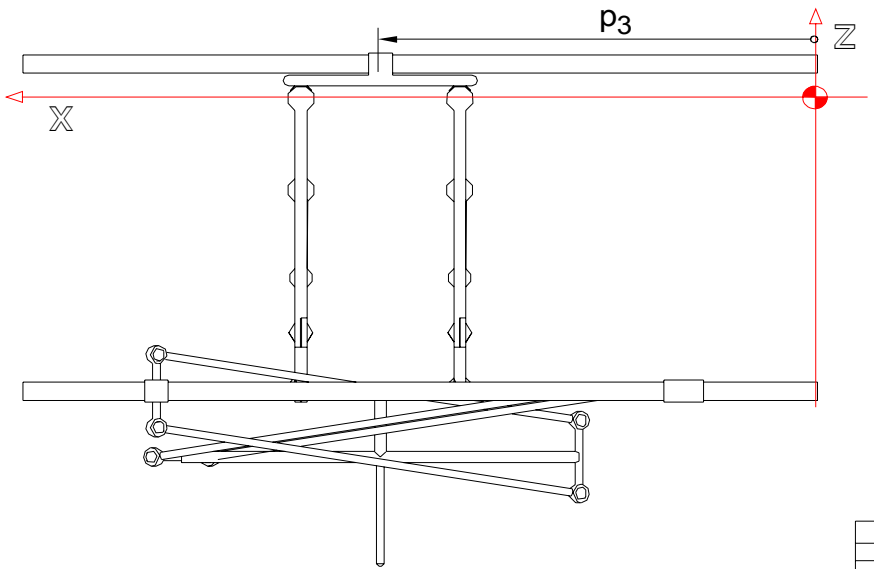

pn0102-4

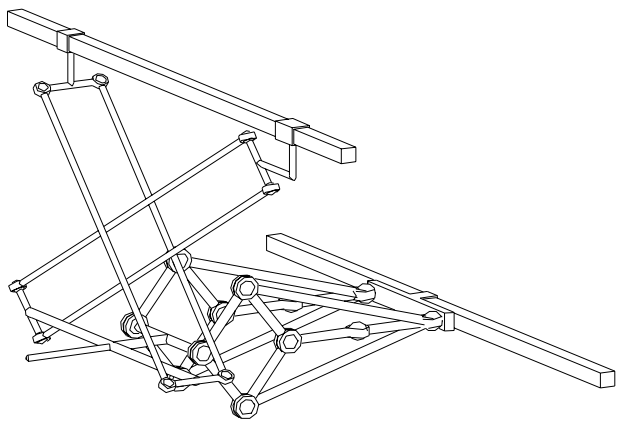

pn0102-4

Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom









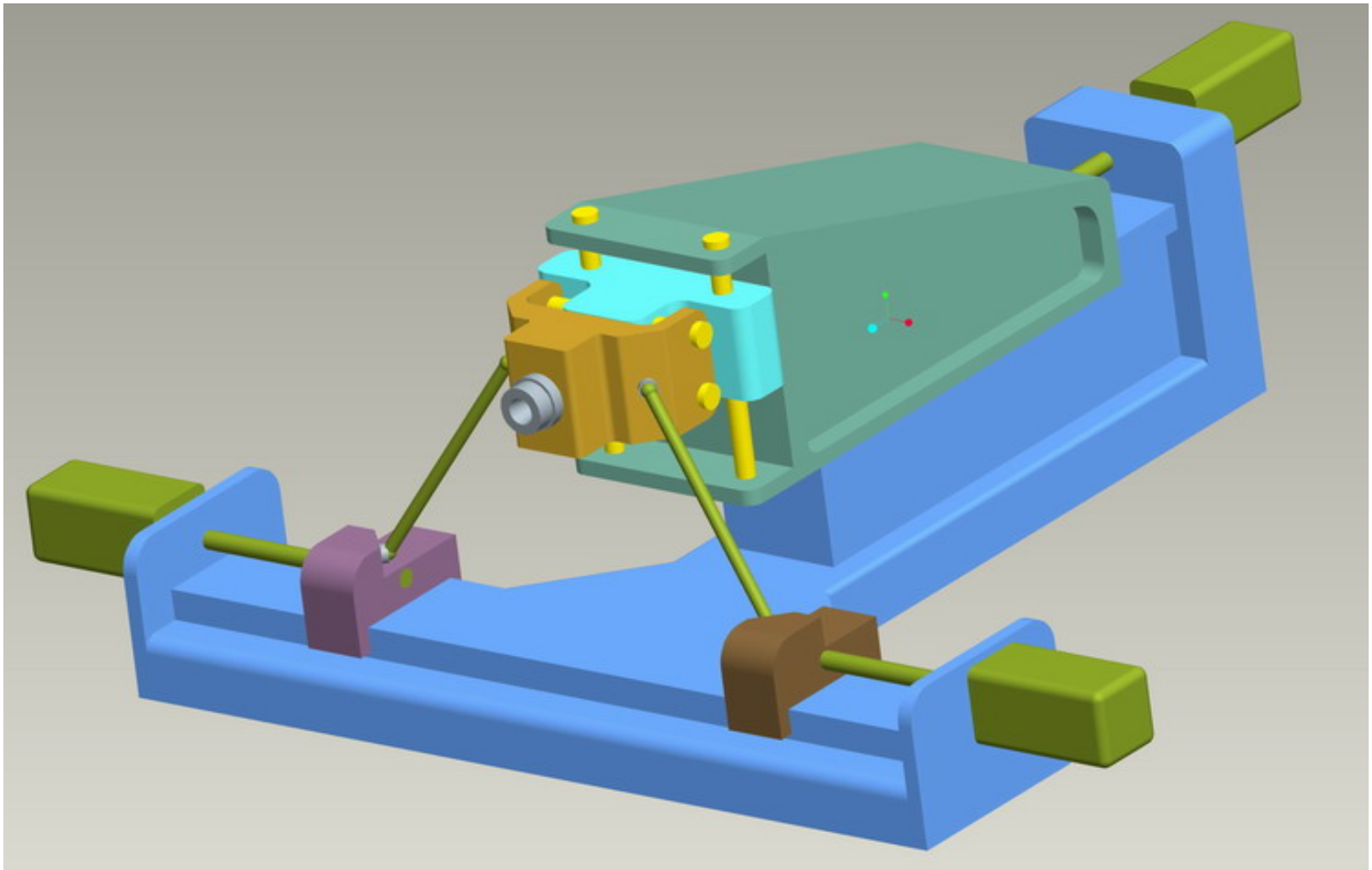
	PROJEKTNI TIM	potpis	datum	18.11.2004.
	dr Miloš Glavonjić			
	dr Dragan Milutinović			
	mr Saša Živanović			

Mašinski fakultet Beograd
KaProM

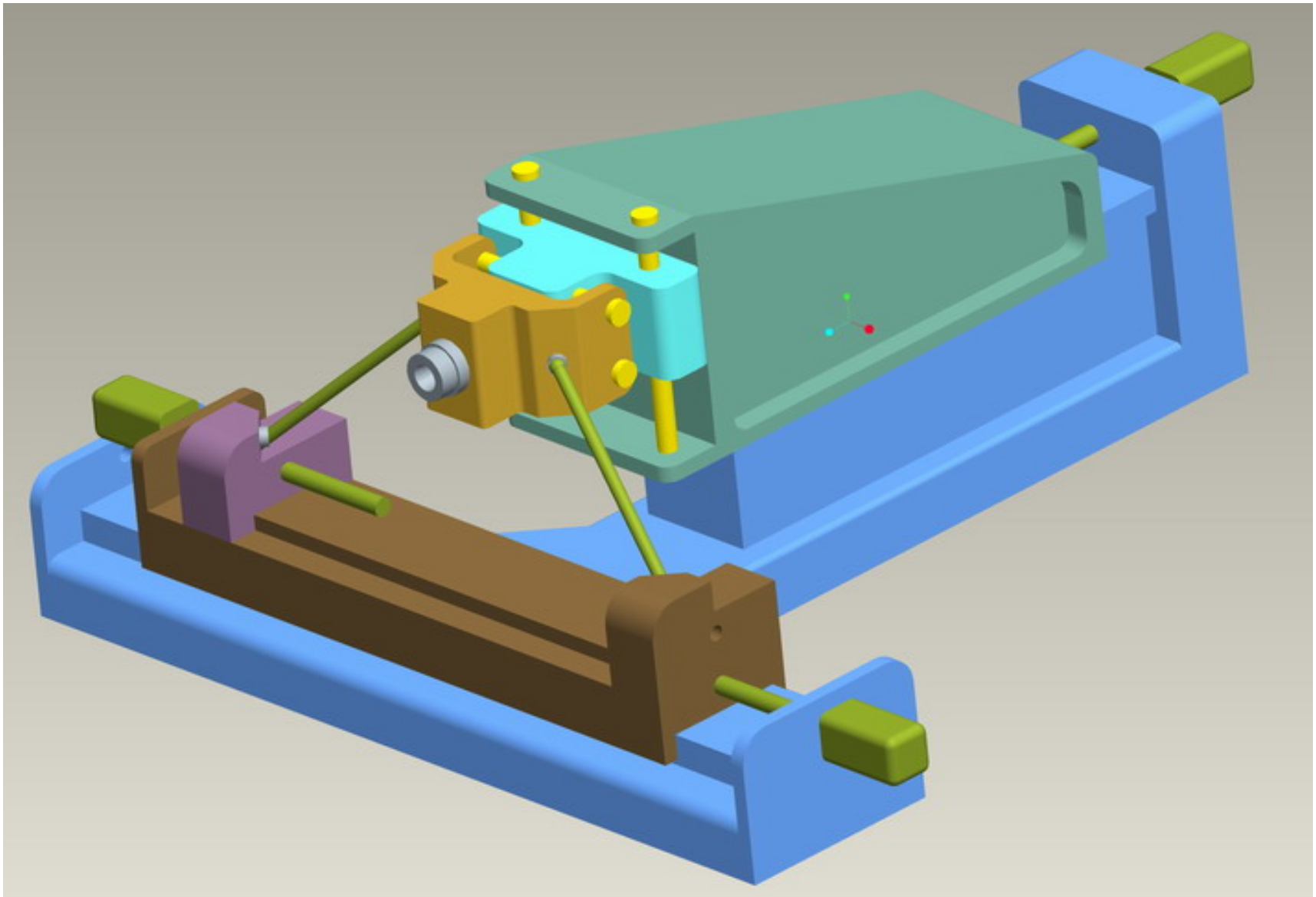
Naziv: **pn 102-4**
Troosna horizontalna glodalica sa paralelnom kinematikom ("pasivni zglob - Peaucellier")

Oznaka: pn102 -4
Listova:
List:
Izvor pod.:
Zamena za:

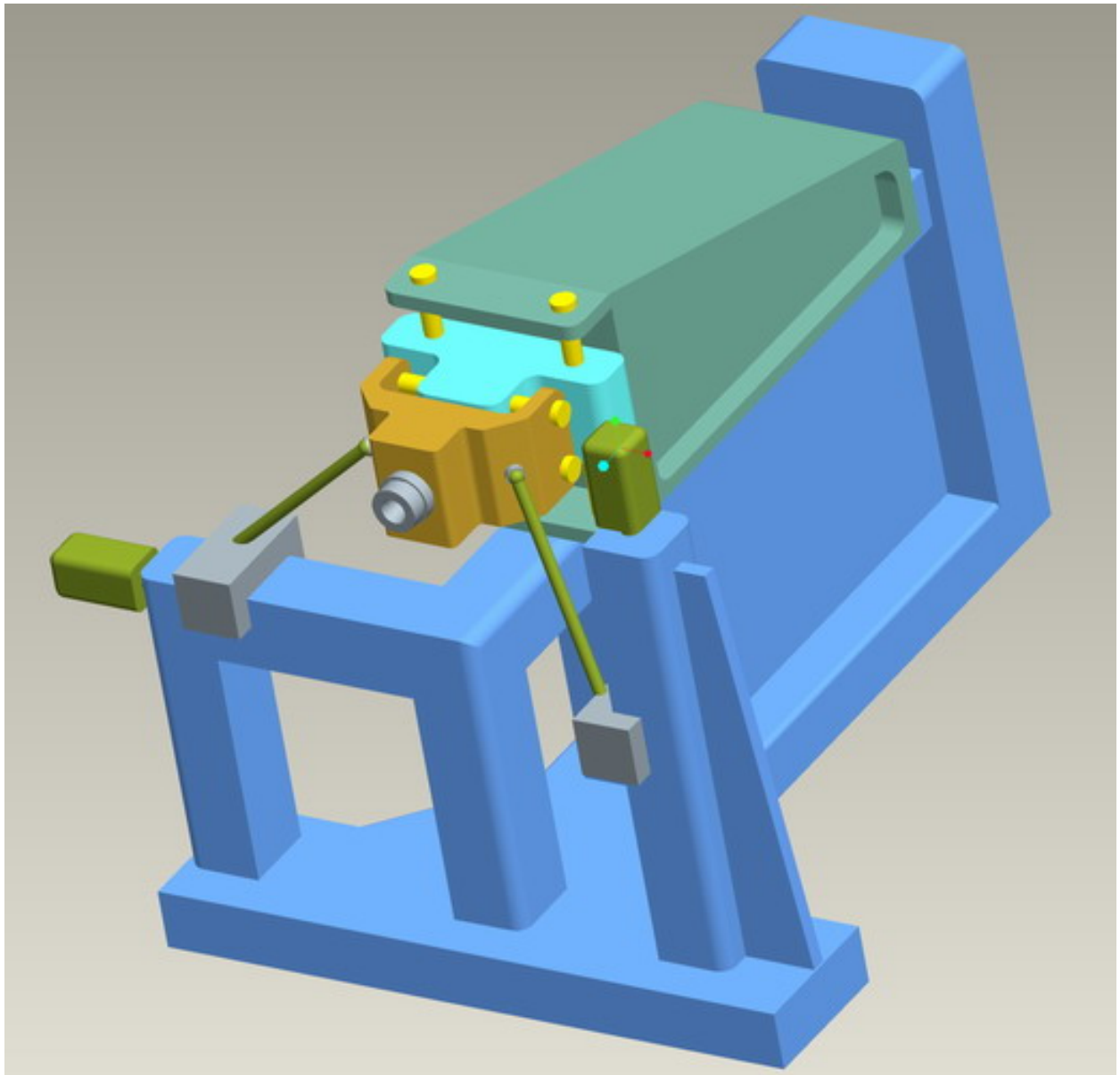
Ostale varijante mehanizma za diskusiju

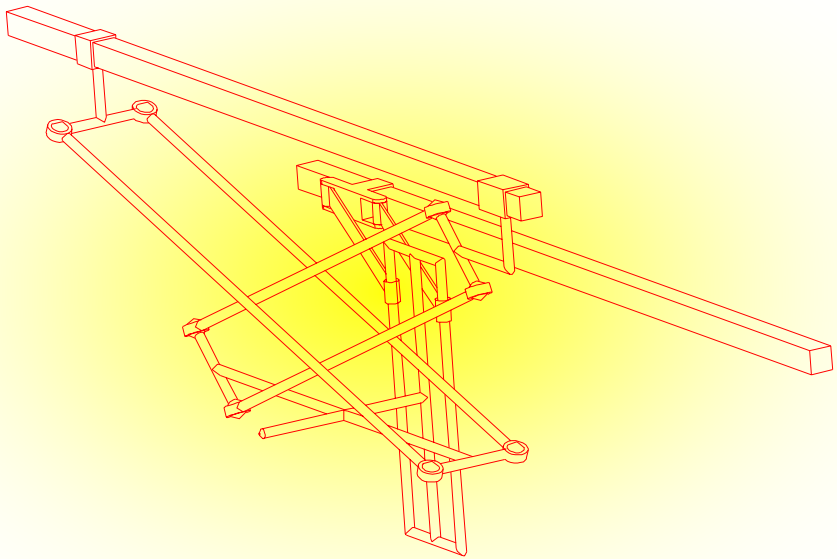


Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom



Polazne koncepcije prototipa troosne horizontalne mašine sa paralelnom kinematikom





Hvala na paznji!

Dr Dragan Milutinović, Dr Miloš Glavonjić, Mr Saša Živanović