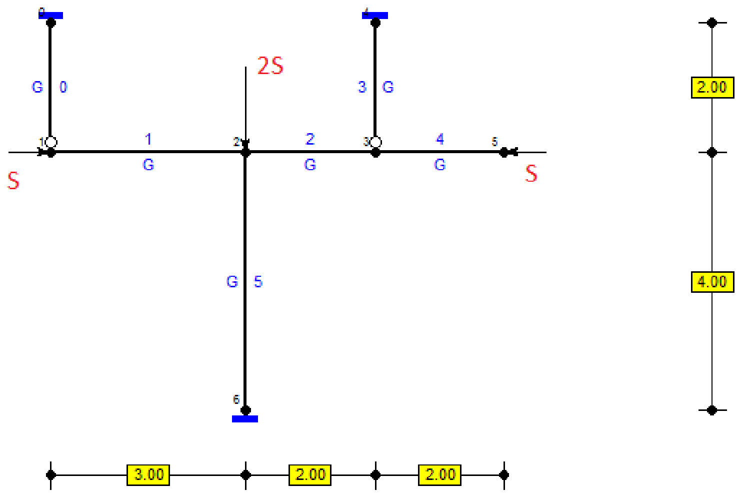
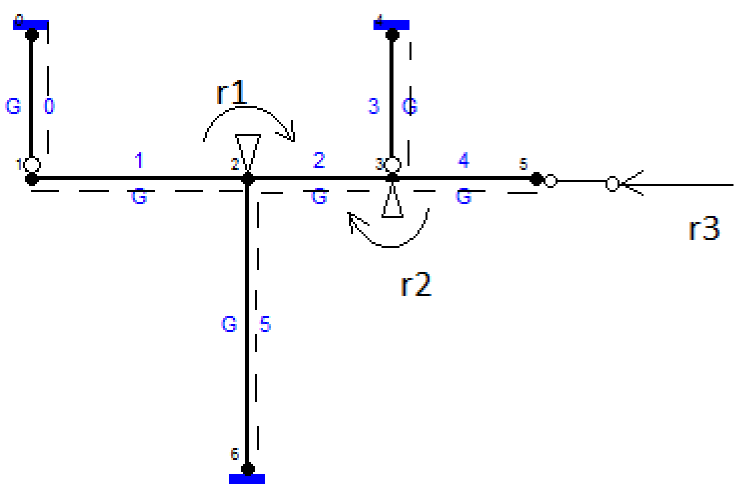
$EJ := 605cm^4 \cdot 205GPa = 1240.25 \cdot kN \cdot m^2$



UPMP



Wyznaczenie α dla poszczególnych prętów na których przyłożone są siły S

Przyjęto że α będzie dla prętów 2 i 4 (są najkrótsze)

pręty 2 i 4 $\quad \alpha^2 = \frac{S \cdot l^2}{EJ} \qquad \alpha = \sqrt{\frac{S \cdot l^2}{EJ}}$

pręt 1 $\quad \alpha_1^{\ 2} = \frac{S \cdot \left(\frac{3}{2} l\right)^2}{EJ} \qquad \alpha_1 = 1.5\alpha$

ponieważ pręt 1 jest 3/2 razy dłuższy od prętów 2 i 4 oraz na pręcie 1 działa taka sama siła jak na prętach 2 i 4

pręt 5 $\quad \alpha_1^{\ 2} = \frac{2S \cdot \left(\frac{4}{2} l\right)^2}{EJ} \qquad \alpha_1 = 2\sqrt{2}\alpha$

ponieważ pręt 5 jest 4/2 razy dłuższy od prętów 2 i 4 oraz na pręcie 5 działa 2 razy większa siła niż na prętach 2 i 4

Wzory:

$$d(\alpha) := 2(1 - \cos(\alpha)) - \alpha\cdot\sin(\alpha)$$

$$c(\alpha) := \frac{\alpha}{d(\alpha)}\cdot(\sin(\alpha) - \alpha\cdot\cos(\alpha))$$

$$s(\alpha) := \frac{\alpha}{d(\alpha)}\cdot(\alpha - \sin(\alpha))$$

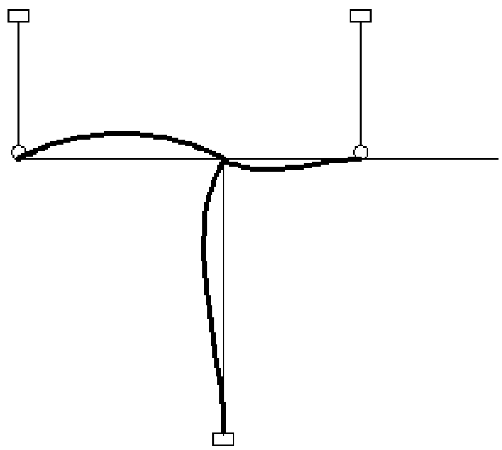
$$r(\alpha) := \frac{\alpha^2}{d(\alpha)}\cdot(1 - \cos(\alpha))$$

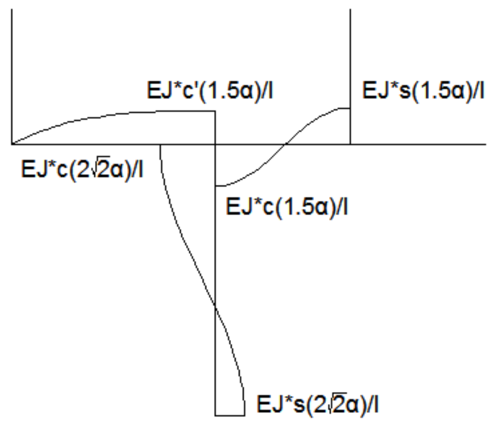
$$c'(\alpha) := \alpha^2\cdot\frac{\sin(\alpha)}{\sin(\alpha) - \alpha\cdot\cos(\alpha)}$$

$$c'''(\alpha) := -\alpha\cdot\frac{\sin(\alpha)}{\cos(\alpha)}$$

$$b(\alpha) := \frac{\alpha^3}{d(\alpha)}\cdot\sin(\alpha)$$

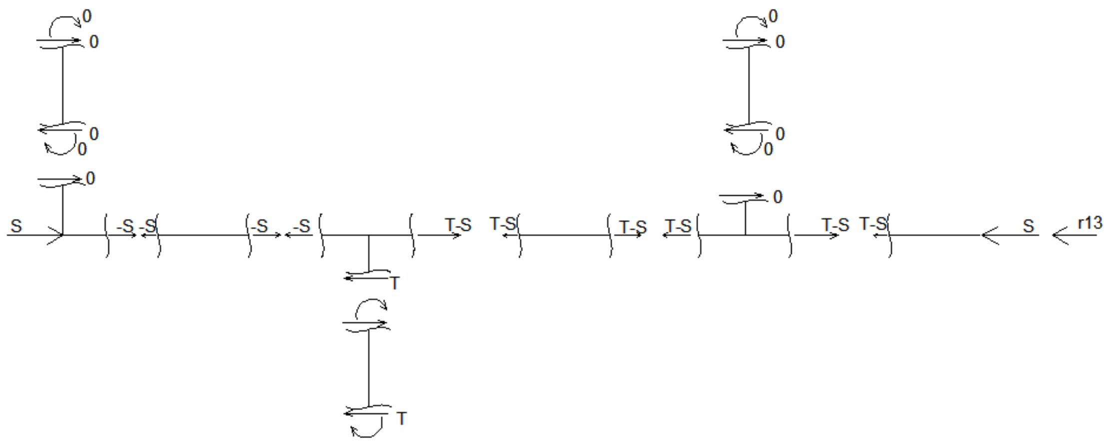
Stan φ1





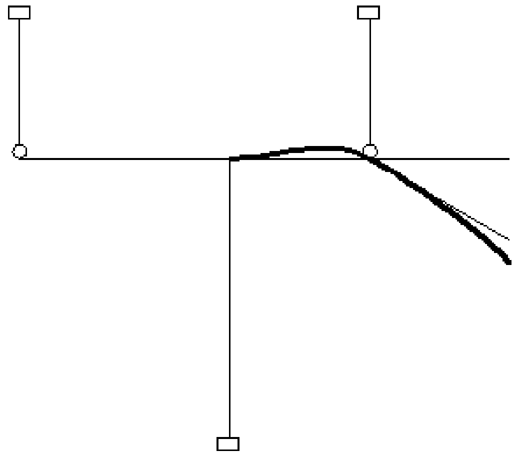
$$r_{11}(\alpha) := EJ\cdot\frac{c'(1.5\alpha)}{3m} + EJ\cdot\frac{c\left(2\sqrt{2}\alpha\right)}{4m} + \frac{EJ\cdot c(\alpha)}{2m}$$

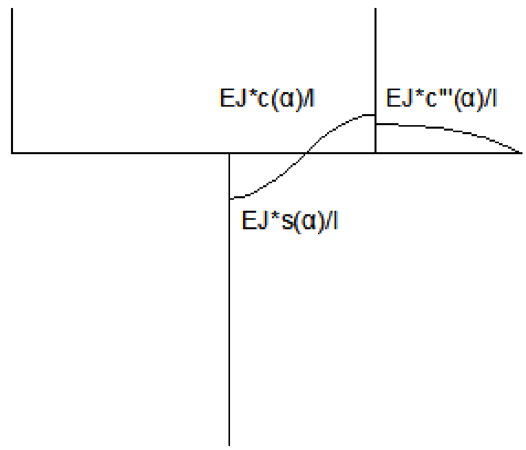
$$r_{12}(\alpha) := \frac{EJ\cdot s(\alpha)}{2m}$$



$$T(\alpha) := \frac{-EJ\cdot r\left(2\sqrt{2}\alpha\right)}{(4m)^2} \qquad r_{13}(\alpha) := -T(\alpha)$$

Stan φ2



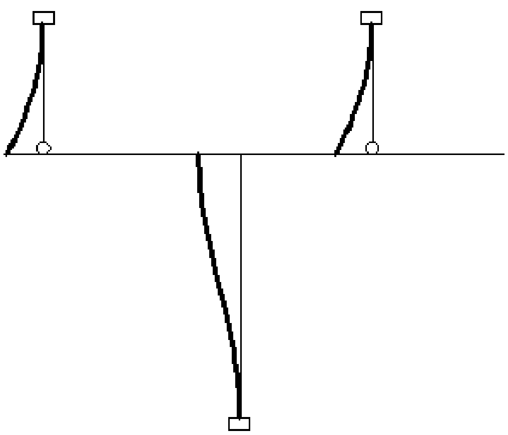


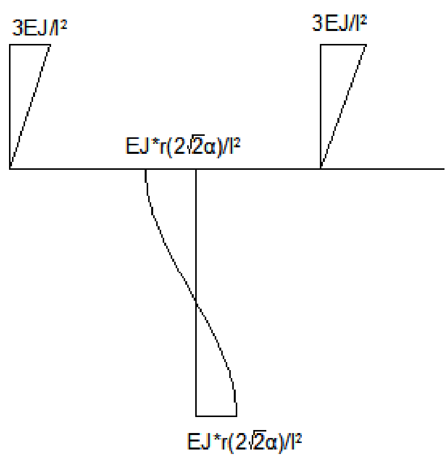
$$r_{21}(\alpha) := \frac{EJ \cdot s(\alpha)}{2m}$$ to samo co r.12

$$r_{22}(\alpha) := \frac{EJ \cdot c(\alpha)}{2m} + \frac{EJ \cdot c'''(\alpha)}{2m}$$

$$r_{23}(\alpha) := 0$$

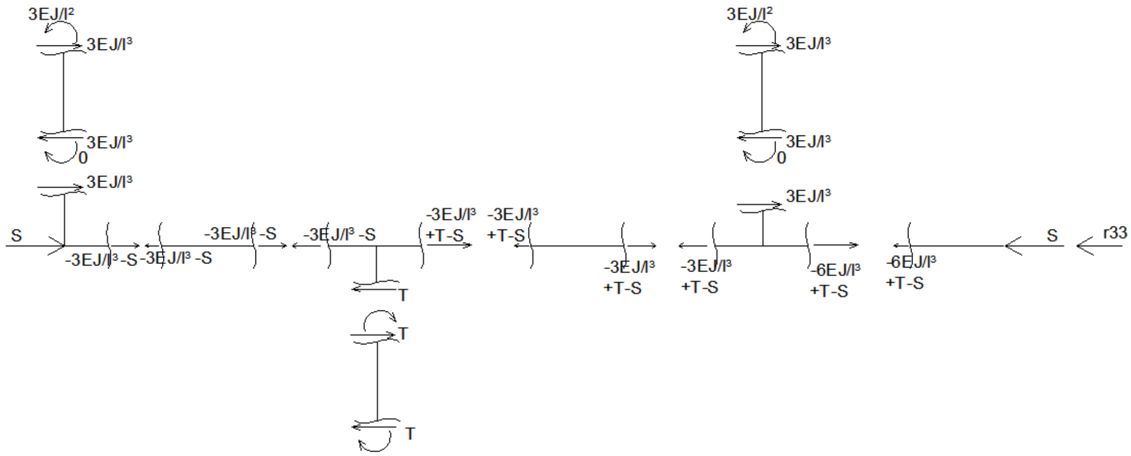
stan Δ3





$$r_{31}(\alpha) := \frac{-EJ \cdot r\left(2\sqrt{2}\alpha\right)}{(4m)^2}$$ to samo co r.13

$$r_{32}(\alpha) := 0$$ to samo co r.23



$$T(\alpha) := \frac{-EJ \cdot b\left(2\sqrt{2}\,\alpha\right)}{(4m)^3} \qquad r_{33}(\alpha) := \frac{6EJ}{(2m)^3} - T(\alpha)$$

Mathcad nie chce dalej liczyć z jednostkami, dlatego zamieniam wszystko bez jednostek

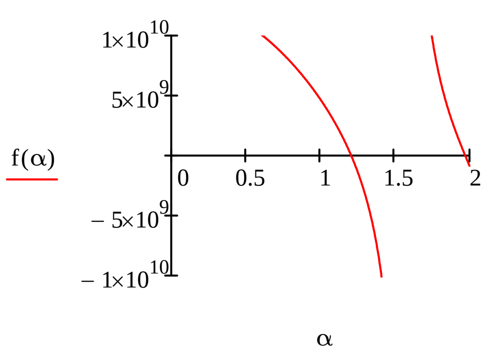
$$r_{11}(\alpha) := \frac{r_{11}(\alpha)}{kN \cdot m} \qquad r_{12}(\alpha) := \frac{r_{12}(\alpha)}{kN \cdot m} \qquad r_{13}(\alpha) := \frac{r_{13}(\alpha)}{kN}$$

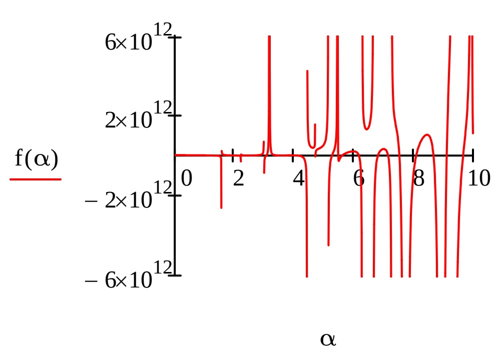
$$r_{21}(\alpha) := \frac{r_{21}(\alpha)}{kN \cdot m} \qquad r_{22}(\alpha) := \frac{r_{22}(\alpha)}{kN \cdot m} \qquad r_{23}(\alpha) := \frac{r_{23}(\alpha)}{kN}$$

$$r_{31}(\alpha) := \frac{r_{31}(\alpha)}{kN} \qquad r_{32}(\alpha) := \frac{r_{32}(\alpha)}{kN} \qquad r_{33}(\alpha) := \frac{r_{33}(\alpha) \cdot m}{kN}$$

ROZWIĄZANIE

$$f(\alpha) := \left| \begin{pmatrix} r_{11}(\alpha) & r_{12}(\alpha) & r_{13}(\alpha) \\ r_{21}(\alpha) & r_{22}(\alpha) & r_{23}(\alpha) \\ r_{31}(\alpha) & r_{32}(\alpha) & r_{33}(\alpha) \end{pmatrix} \right|$$





Given

$\alpha := 1$

$f(\alpha) = 0$

$\alpha := \mathrm{Find}(\alpha) = 1.207$

$$S := \frac{\alpha^2 \cdot EJ}{(2m)^2} = 451.532 \cdot kN$$

Wynik z soldisa

w Soldisie wprowadzono siły 1kN i 2kN,
λ jest to mnożnik krytyczny czyli wielokrotność wprowadzonych sił (najmniejsza siła to 1kN,
więc siła krytyczna jest to 457.319kN wg Soldisa)