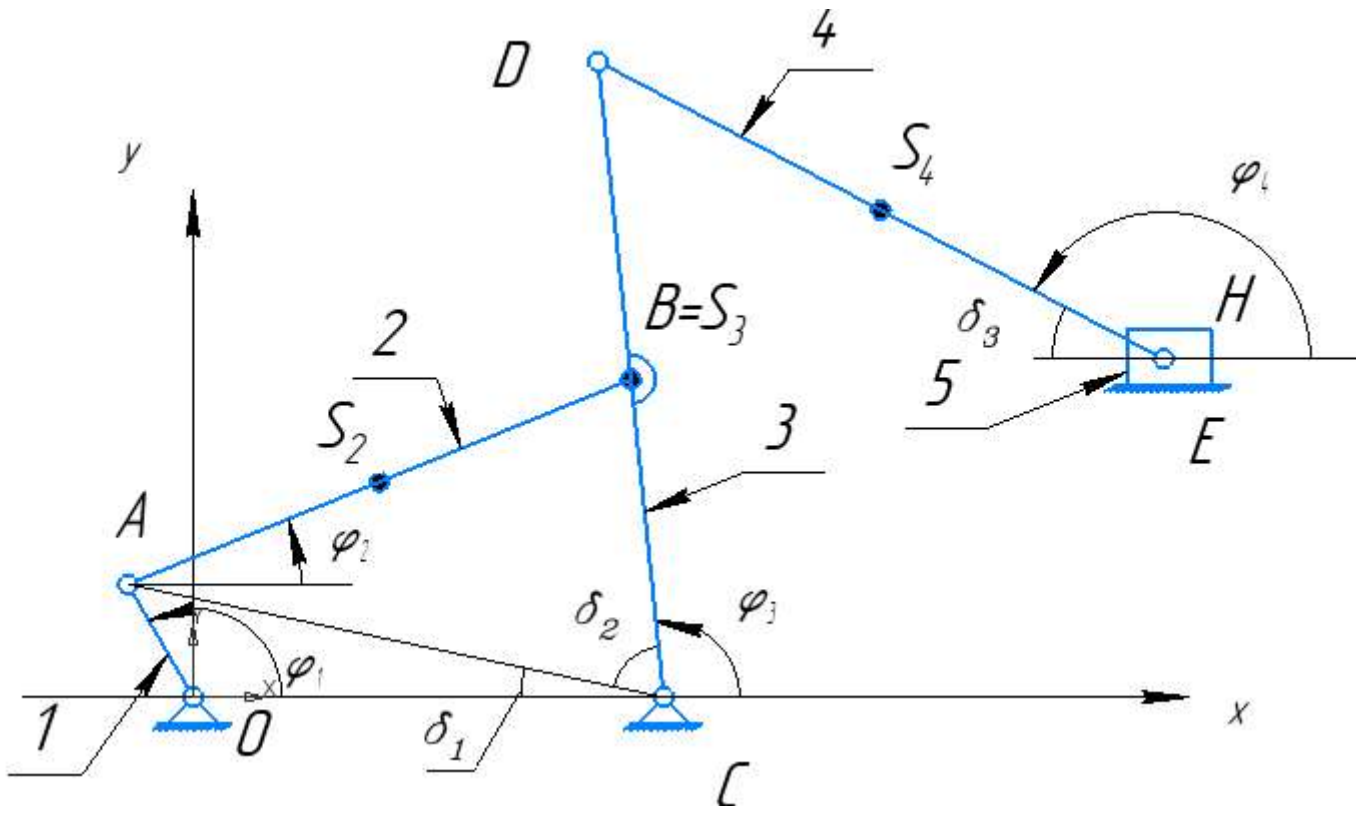
т



Дано:

$l_{OA} := 0.347$ $l_{AS2} := 0.7225$ $l_{S2B} := 0.723$ $f := 99.1deg$ $l_{DH} := 1.7$

$l_{AB} := 1.445$ $l_{DS4} := 0.85$ $Y_H := 0.9$ $l_{S4H} := 0.85$ $X_C := 1.25$

$l_{BC} := 0.85$ $l_{CD} := 1.7$ $\varphi_0 := 219.1deg$ $Y_C := 0$

Составление расчетной схемы:

$\varphi_1(\varphi) := \varphi_0 - \varphi$

$X_A(\varphi) := l_{OA}\cdot\cos(\varphi_1(\varphi))$

$Y_A(\varphi) := l_{OA}\cdot\sin(\varphi_1(\varphi))$

$$l_{AC}(\varphi) := \sqrt{(l_{OA})^2 + X_C{}^2 - 2\cdot X_C\cdot l_{OA}\cdot\cos(\varphi_1(\varphi))}$$

$$\delta_1(\varphi) := \operatorname{asin}\left(\frac{l_{OA}\cdot\sin(\varphi_1(\varphi))}{l_{AC}(\varphi)}\right)$$

$$\delta_2(\varphi) := \operatorname{acos}\left[\frac{\left(l_{AC}(\varphi)^2 + l_{BC}{}^2 - l_{AB}{}^2\right)}{2\,l_{AC}(\varphi)\cdot l_{BC}}\right]$$

$\varphi_3(\varphi) := \pi - \delta_1(\varphi) - \delta_2(\varphi)$

$X_B(\varphi) := l_{BC}\cdot\cos(\varphi_3(\varphi)) + X_C$

$Y_B(\varphi) := l_{BC}\cdot\sin(\varphi_3(\varphi))$

$$\varphi_2(\varphi) := \operatorname{atan}\left(\frac{Y_B(\varphi) - Y_A(\varphi)}{X_B(\varphi) - X_A(\varphi)}\right)$$

$X_{S2}(\varphi) := X_A(\varphi) + l_{AS2}\cdot\cos(\varphi_2(\varphi))$

$X_O(\varphi) := 0$

$Y_O(\varphi) := 0$

$\varphi_1(f) = 120\cdot deg$

$X_A(f) = -0.174$

$Y_A(f) = 0.301$

$l_{AC}(f) = 1.455$

$\delta_1(f) = 11.921\cdot deg$

$\delta_2(f) = 72.32\cdot deg$

$\varphi_3(f) = 95.759\cdot deg$

$X_B(f) = 1.165$

$Y_B(f) = 0.846$

$\varphi_2(f) = 22.167\cdot deg$

$X_{S2}(f) = 0.496$

$$Y_{S2}(\varphi) := Y_A(\varphi) + l_{AS2}\cdot\sin\left(\varphi_2(\varphi)\right) \qquad Y_{S2}(f) = 0.573$$

$$Y_D(\varphi) := l_{CD}\cdot\sin\left(\varphi_3(\varphi)\right) \qquad Y_D(f) = 1.691$$

$$X_D(\varphi) := l_{CD}\cdot\cos\left(\varphi_3(\varphi)\right) + X_C \qquad X_D(f) = 1.079$$

$$\delta_3(\varphi) := \operatorname{asin}\left(\frac{Y_D(\varphi) - Y_H}{l_{DH}}\right) \qquad \delta_3(f) = 27.745\cdot\text{deg}$$

$$X_H(\varphi) := l_{DH}\cdot\cos\left(\delta_3(\varphi)\right) + X_D(\varphi) \qquad X_H(f) = 2.584$$

$$\varphi_4(\varphi) := \pi - \delta_3(\varphi) \qquad \varphi_4(f) = 152.255\cdot\text{deg}$$

$$X_{S4}(\varphi) := X_H(\varphi) + l_{DS4}\cdot\cos\left(\varphi_4(\varphi)\right) \qquad X_{S4}(f) = 1.832$$

$$Y_{S4}(\varphi) := Y_H + l_{DS4}\cdot\sin\left(\varphi_4(\varphi)\right) \qquad Y_{S4}(f) = 1.296$$

$$X_{S3}(\varphi) := X_B(\varphi) \qquad X_{S3}(f) = 1.165$$

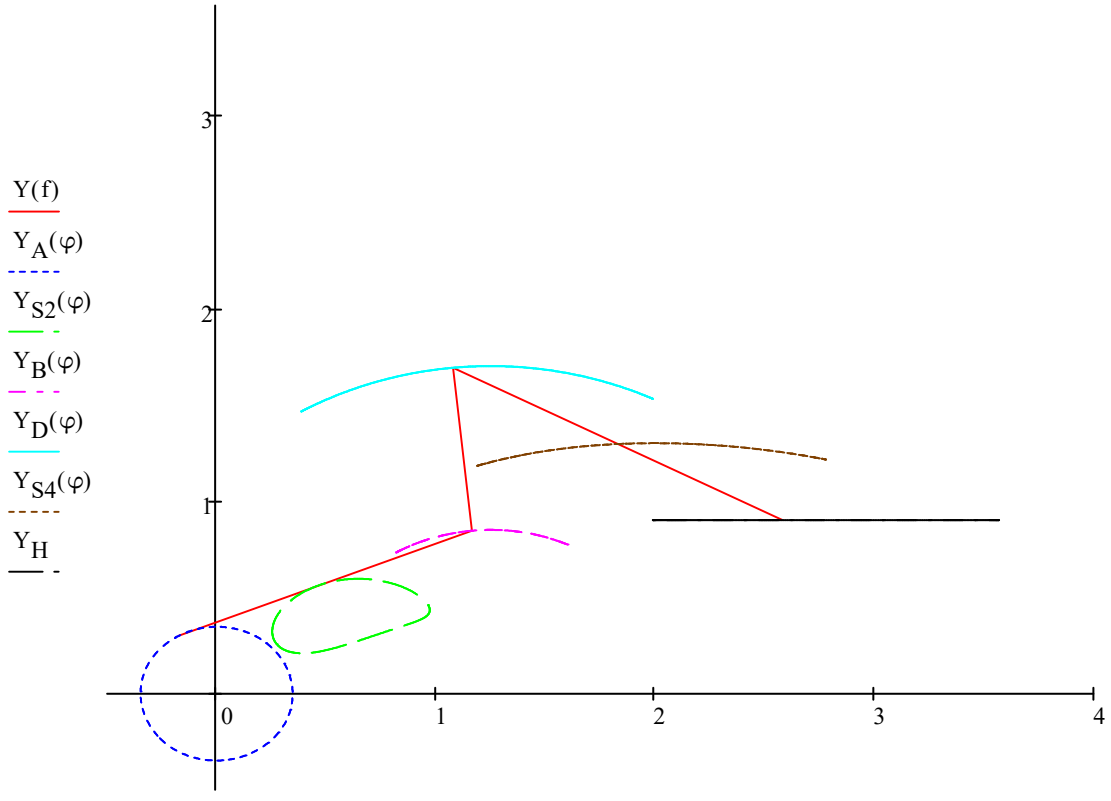
$$Y_{S3}(\varphi) := Y_B(\varphi) \qquad Y_{S3}(f) = 0.846$$

Построение проверочной схемы:

$$X(\varphi) := \left(X_A(\varphi)\ \ X_{S2}(\varphi)\ \ X_B(\varphi)\ \ X_D(\varphi)\ \ X_{S4}(\varphi)\ \ X_H(\varphi)\right)^T$$

$$Y(\varphi) := \left(Y_A(\varphi)\ \ Y_{S2}(\varphi)\ \ Y_B(\varphi)\ \ Y_D(\varphi)\ \ Y_{S4}(\varphi)\ \ Y_H\right)^T$$

$$\varphi := 0, 0.01 .. 2\pi$$



$$X(f), X_A(\varphi), X_{S2}(\varphi), X_B(\varphi), X_D(\varphi), X_{S4}(\varphi), X_H(\varphi)$$

Определение аналогов скоростей:

$$V_{qBx}(\varphi) := \frac{d}{d\varphi} X_B(\varphi) \qquad V_{qBx}(f) = 0.357$$

$$V_{qBy}(\varphi) := \frac{d}{d\varphi} Y_B(\varphi) \qquad V_{qBy}(f) = 0.036$$

$$V_{qS2x}(\varphi) := \frac{d}{d\varphi} X_{S2}(\varphi) \qquad V_{qS2x}(f) = 0.329$$

$$V_{qS2y}(\varphi) := \frac{d}{d\varphi} Y_{S2}(\varphi) \qquad V_{qS2y}(f) = 0.105$$

$$V_{qS4x}(\varphi) := \frac{d}{d\varphi} X_{S4}(\varphi) \qquad V_{qS4x}(f) = 0.694$$

$$V_{qS4y}(\varphi) := \frac{d}{d\varphi} Y_{S4}(\varphi) \qquad V_{qS4y}(f) = 0.036$$

Угловые аналоги:

$$\omega_{q1}(\varphi) := \frac{d}{d\varphi} \varphi_1(\varphi) \qquad \omega_{q1}(f) = -1$$

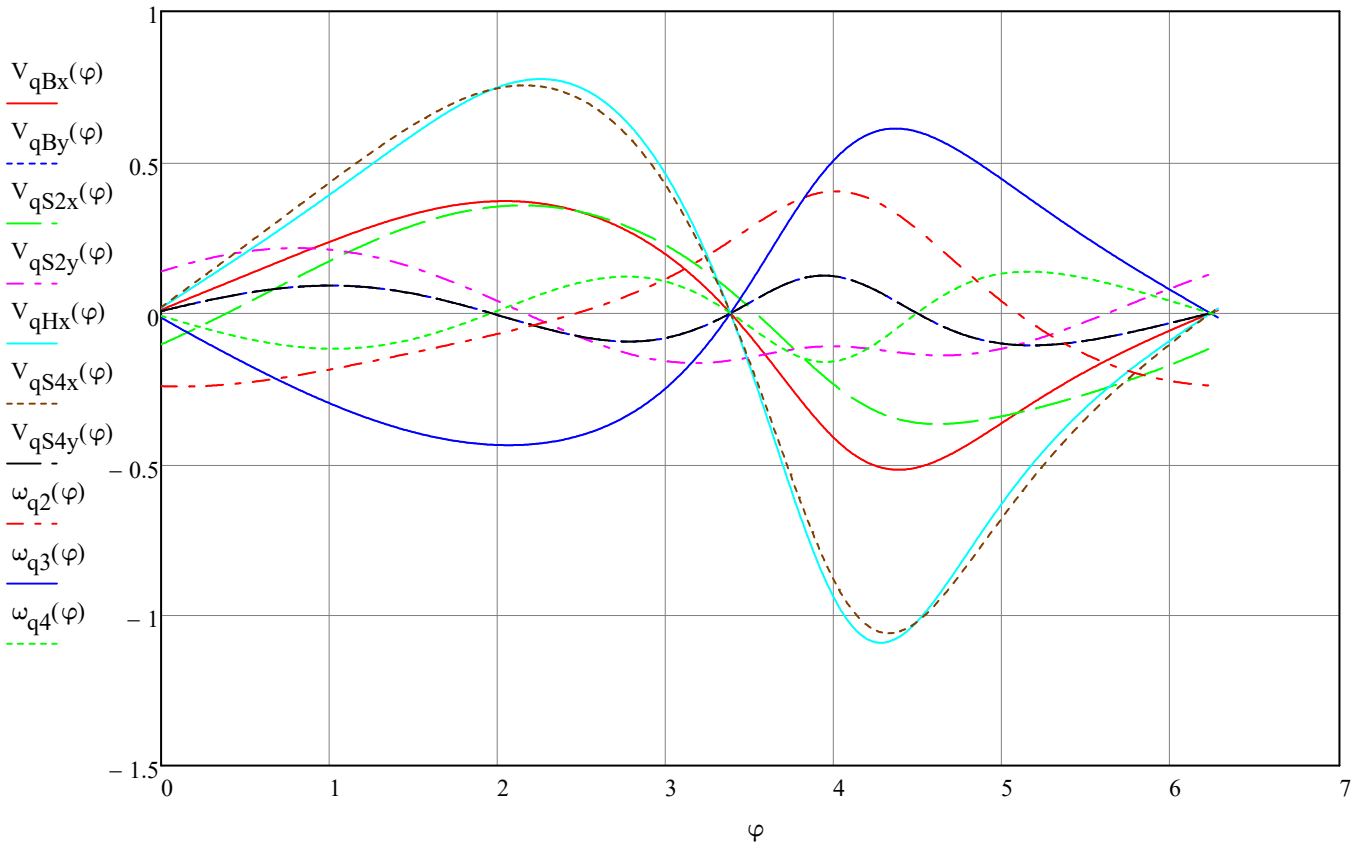
$$\omega_{q2}(\varphi) := \frac{d}{d\varphi} \varphi_2(\varphi) \qquad \omega_{q2}(f) = -0.103$$

$$\omega_{q4}(\varphi) := \frac{d}{d\varphi} \varphi_4(\varphi) \qquad \omega_{q4}(f) = -0.048$$

$$\omega_{q3}(\varphi) := \frac{d}{d\varphi} \varphi_3(\varphi) \qquad \omega_{q3}(f) = -0.422$$

$$V_{qHx}(\varphi) := \frac{d}{d\varphi} X_H(\varphi) \qquad V_{qHx}(f) = 0.675$$

$$V_{qHy}(\varphi) := \frac{d}{d\varphi} Y_H \qquad V_{qHy}(f) = 0$$



Определение аналогов ускорений:

$$a_{qBx}(\varphi) := \frac{d^2}{d\varphi^2} X_B(\varphi) \qquad a_{qBx}(f) = 0.093$$

$$a_{qBy}(\varphi) := \frac{d^2}{d\varphi^2} Y_B(\varphi) \qquad a_{qBy}(f) = -0.143$$

$$a_{qHx}(\varphi) := \frac{d^2}{d\varphi^2} X_H(\varphi) \qquad a_{qHx}(f) = 0.331$$

$$a_{qHy}(\varphi) := \frac{d^2}{d\varphi^2} Y_H \qquad a_{qHy}(f) = 0$$

Угловые аналоги:

$$\varepsilon_{q1}(\varphi) := \frac{d^2}{d\varphi^2} \varphi_1(\varphi)$$

$$\varepsilon_{q2}(\varphi) := \frac{d^2}{d\varphi^2} \varphi_2(\varphi)$$

$$\varepsilon_{q3}(\varphi) := \frac{d^2}{d\varphi^2} \varphi_3(\varphi)$$

$$\varepsilon_{q4}(\varphi) := \frac{d^2}{d\varphi^2} \varphi_4(\varphi)$$

$a_{qS2x}(\varphi) := \frac{d^2}{d\varphi^2} X_{S2}(\varphi)$ $a_{qS2x}(f) = 0.133$

$a_{qS2y}(\varphi) := \frac{d^2}{d\varphi^2} Y_{S2}(\varphi)$ $a_{qS2y}(f) = -0.222$

$a_{qS4x}(\varphi) := \frac{d^2}{d\varphi^2} X_{S4}(\varphi)$ $a_{qS4x}(f) = 0.258$

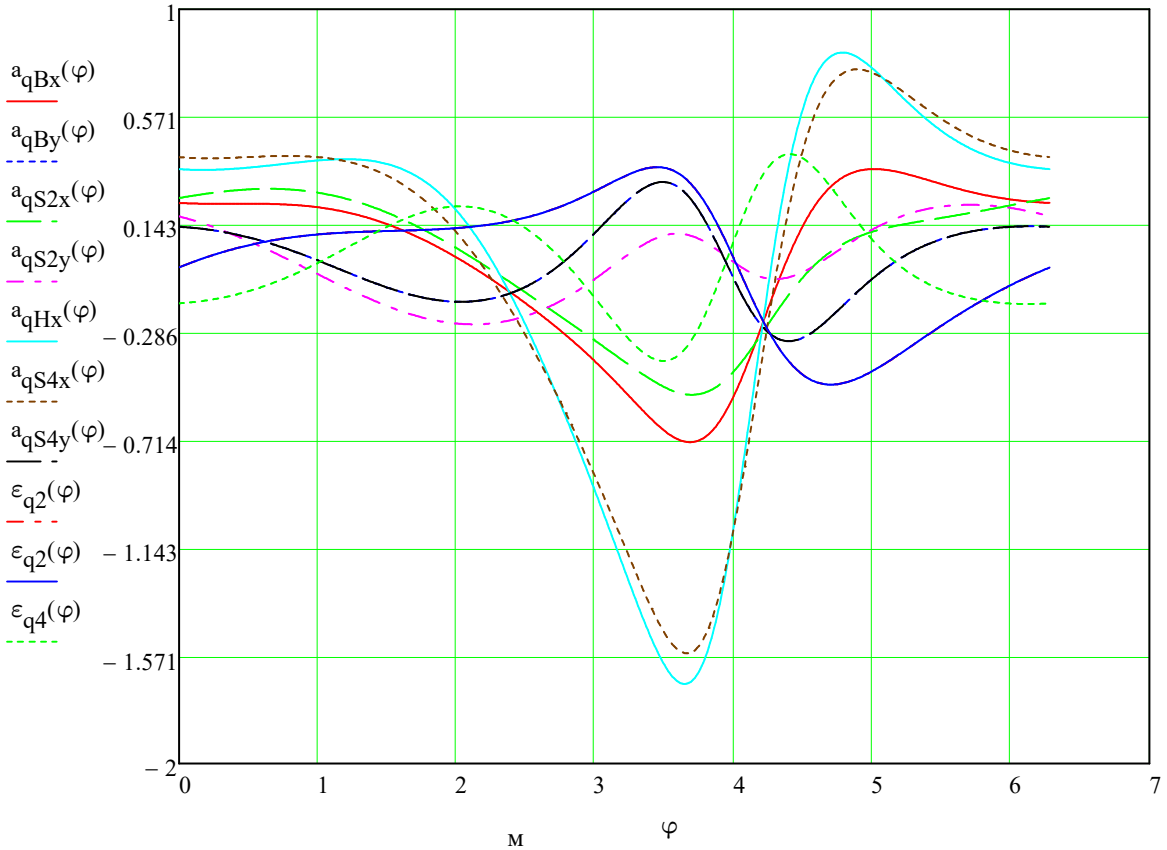
$a_{qS4y}(\varphi) := \frac{d^2}{d\varphi^2} Y_{S4}(\varphi)$ $a_{qS4y}(f) = -0.143$

$\varepsilon_{q1}(f) = -1.502 \times 10^{-14}$

$\varepsilon_{q2}(f) = 0.122$

$\varepsilon_{q3}(f) = -0.092$

$\varepsilon_{q4}(f) = 0.188$



$g := 9.81 \frac{м}{с^2}$

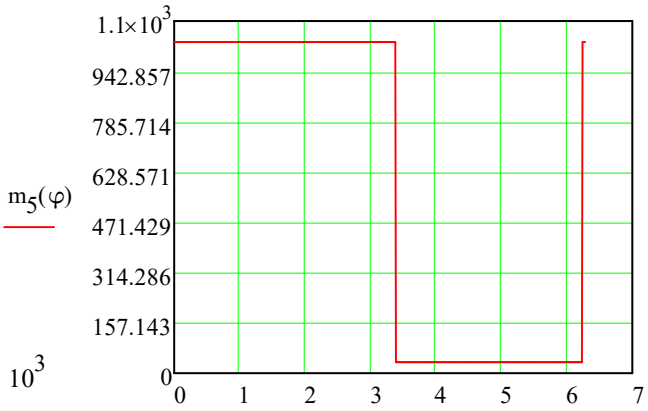
$G_2 := 90 \cdot g = 882.9\ Н$ $G_3 := 160 \cdot g = 1.57 \times 10^{3}\ Н$ $G_4 := 220 \cdot g = 2.158 \times 10^{3}\ Н$ $G_{51} := 35 \cdot g = 343.35\ Н$

$M := 1000\ кг$ масса заготовки

$k := 0.04$ Коэф трения качения $P_{п.с} := M \cdot k \cdot g = 392.4\ Н$

$m_2 := \frac{G_2}{g} кг$ $m_3 := \frac{G_3}{g} кг$ $m_4 := \frac{G_4}{g} кг$

$$m_5(\varphi) := \begin{cases} \frac{G_{51}}{g} & \text{if } V_{qHx}(\varphi) \le 0 \\ \frac{G_{51}}{g} + M & \text{if } V_{qHx}(\varphi) > 0 \end{cases}$$



$m_5(f) = 1.035 \times 10^3$

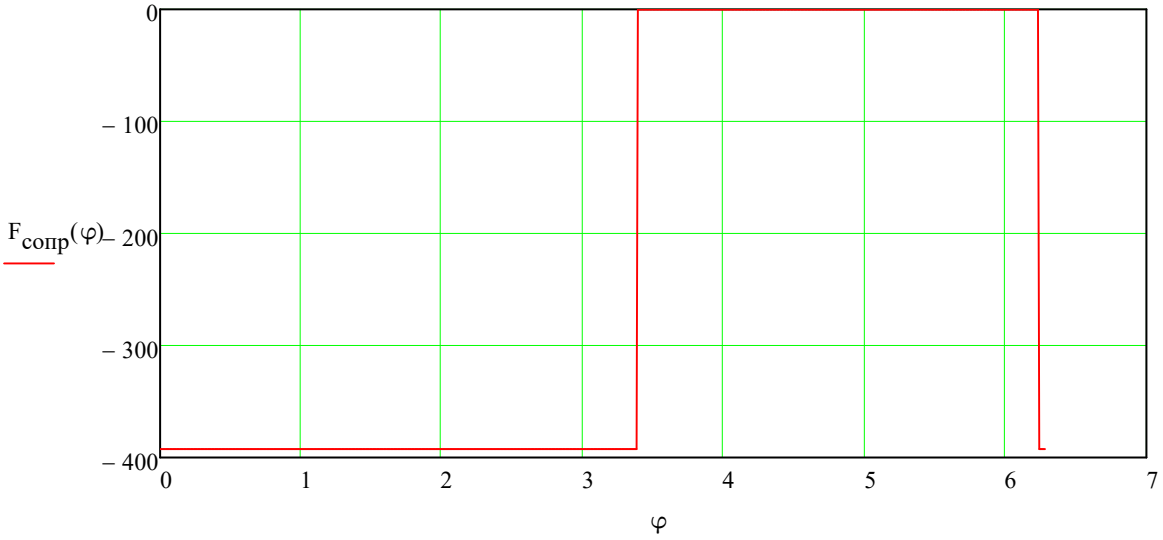
$G_5(\varphi) := m_5(\varphi)\, g$

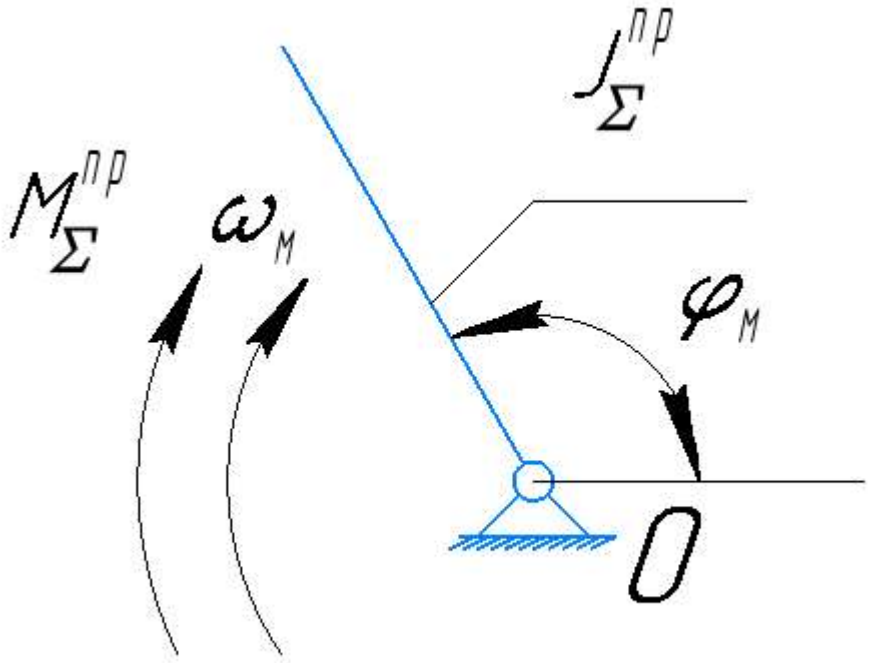
$G_5(f) = 1.015 \times 10^4$

$J_{S2} := 0.45 \cdot g = 4.415$ кг·м^2 $J_{S3} := 0.55 \cdot g = 5.396$ кг·м^2 $J_{S4} := 1.61 \cdot g = 15.794$ кг·м^2

$J_{к5} := 0.052 \cdot g = 0.51$ кг·м^2 $J_{к6} := 0.063 \cdot g = 0.618$ кг·м^2 $J_{ред} := 0.09 \cdot g = 0.883$ кг·м^2

$F_{сопр}(\varphi) := -P_{п.с} \cdot \left(V_{qHx}(\varphi) \geq 0\right)$





$$J_{2пр2}(\varphi) := m_2\cdot\left(V_{qS2x}(\varphi)^2 + V_{qS2y}(\varphi)^2\right) + \omega_{q2}(\varphi)^2 J_{S2}$$

$$J_{2пр3}(\varphi) := m_3\cdot\left(V_{qBx}(\varphi)^2 + V_{qBy}(\varphi)^2\right) + \omega_{q3}(\varphi)^2 J_{S3}$$

$$J_{2пр4}(\varphi) := m_4\cdot\left(V_{qS4x}(\varphi)^2 + V_{qS4y}(\varphi)^2\right) + \omega_{q4}(\varphi)^2 J_{S4}$$

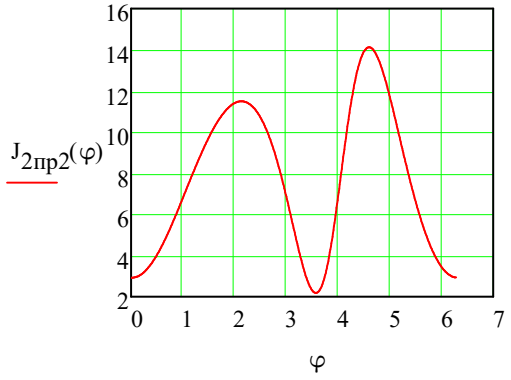
$$J_{2пр5}(\varphi) := m_5(\varphi)\cdot\left(V_{qHx}(\varphi)^2 + V_{qHy}(\varphi)^2\right)$$

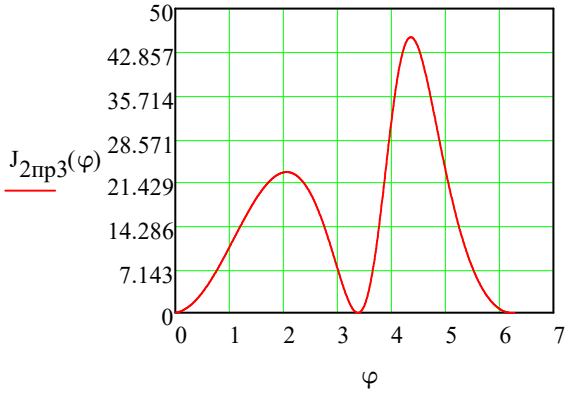
$$J_{2пр}(\varphi) := J_{2пр2}(\varphi) + J_{2пр3}(\varphi) + J_{2пр4}(\varphi) + J_{2пр5}(\varphi) \qquad J_{2пр}(f) = 610.521 \text{ кг}\cdot\text{м}^2$$

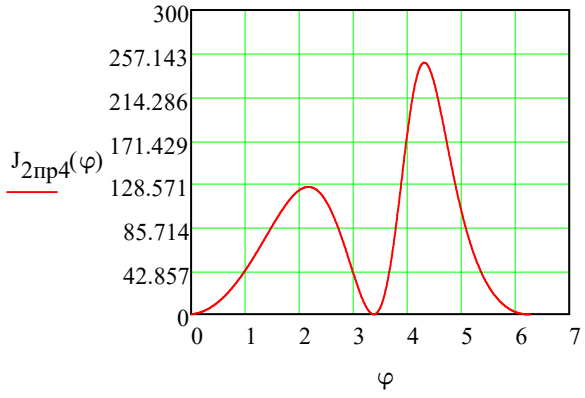
$$dJ_{2пр1}(\varphi) := 2m_3\cdot\left(V_{qBx}(\varphi)\cdot a_{qBx}(\varphi) + V_{qBy}(\varphi)\cdot a_{qBy}(\varphi)\right) + 2m_2\cdot\left(V_{qS2x}(\varphi)\cdot a_{qS2x}(\varphi) + V_{qS2y}(\varphi)\cdot a_{qS2y}(\varphi)\right)$$

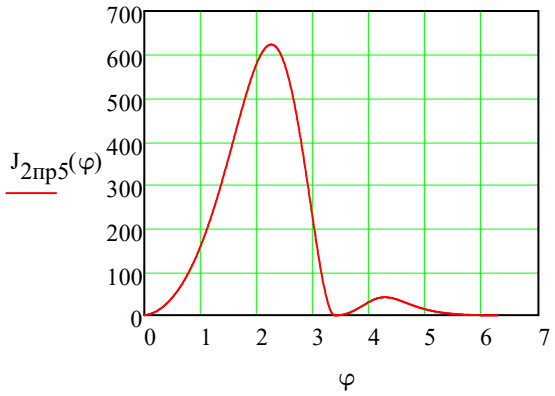
$$dJ_{2пр2}(\varphi) := 2\,\omega_{q4}(\varphi)J_{S4}\cdot\varepsilon_{q4}(\varphi) + 2\,\omega_{q3}(\varphi)J_{S3}\cdot\varepsilon_{q3}(\varphi) + 2m_4\cdot\left(V_{qS4x}(\varphi)\cdot a_{qS4x}(\varphi) + V_{qS4y}(\varphi)\cdot a_{qS4y}(\varphi)\right)$$

$$dJ_{2пр}(\varphi) := dJ_{2пр1}(\varphi) + dJ_{2пр2}(\varphi) + 2\,\omega_{q2}(\varphi)J_{S2}\cdot\varepsilon_{q2}(\varphi) + 2\,m_5(\varphi)\cdot\left(V_{qHx}(\varphi)\cdot a_{qHx}(\varphi) + V_{qHy}(\varphi)\cdot a_{qHy}(\varphi)\right)$$









$M_1(\varphi) := -G_2 \cdot V_{qS2y}(\varphi)$

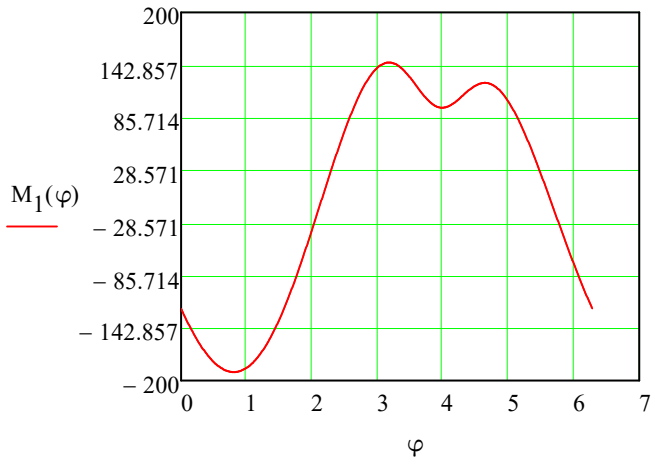
$M_2(\varphi) := -G_3 \cdot V_{qBy}(\varphi)$

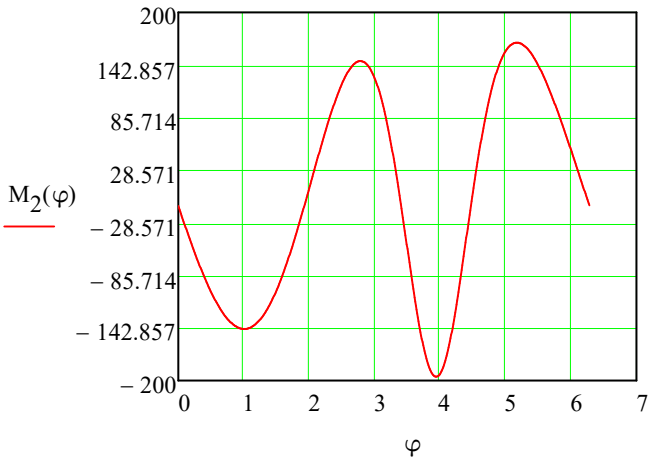
$M_3(\varphi) := -G_4 \cdot V_{qS4y}(\varphi)$

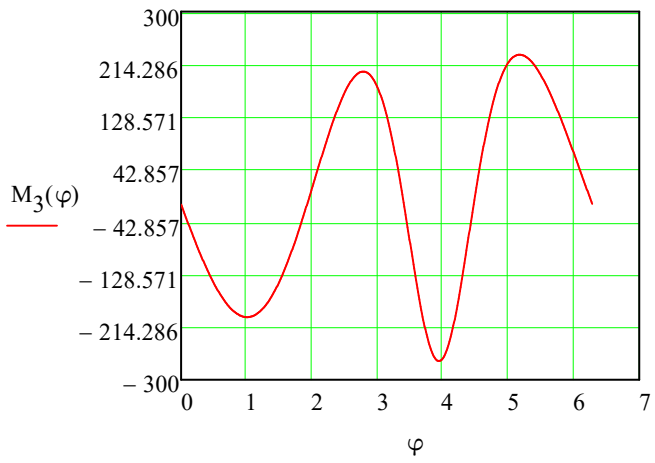
$M_4(\varphi) := F_{сопр}(\varphi) \cdot V_{qHx}(\varphi)$

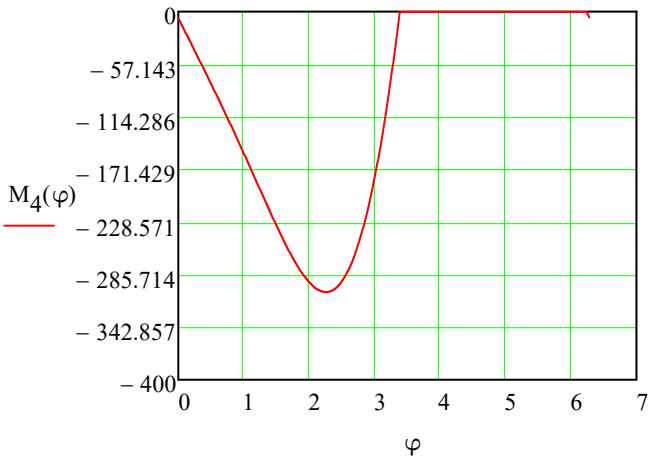
$M_{пр.с}(\varphi) := M_1(\varphi) + M_2(\varphi) + M_3(\varphi) + M_4(\varphi)$

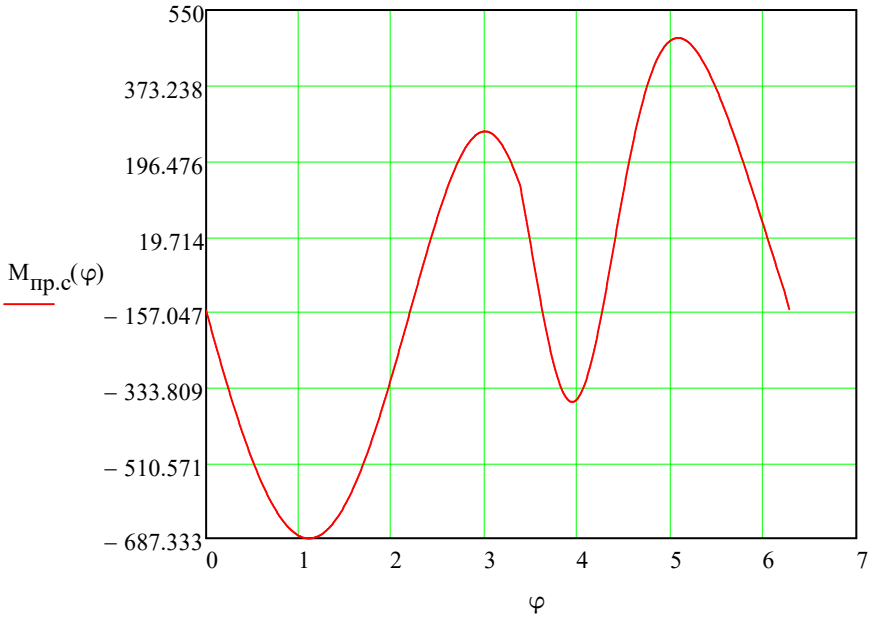
$M_{пр.с}(f) = -491.495$ Н·м

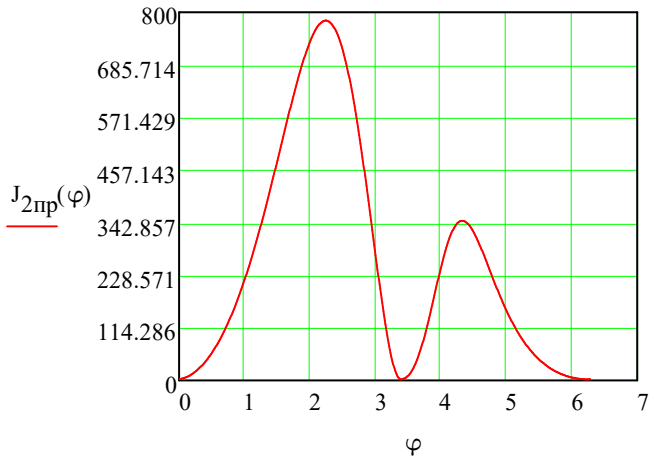


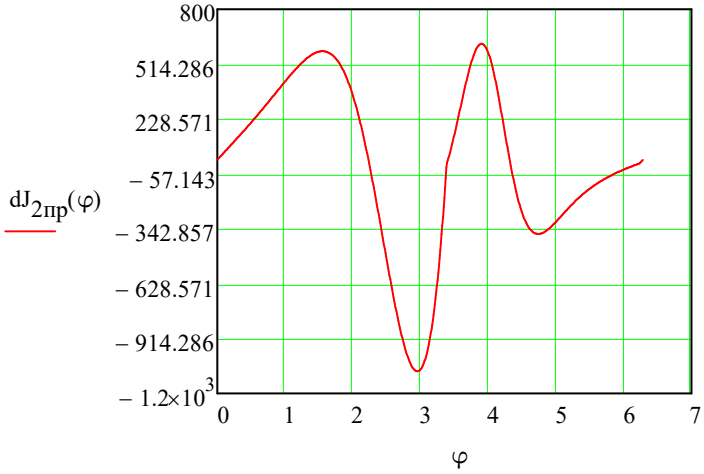












Вычислим работу сил сопротивления за цикл

$$A_c := \int_0^{2\pi} M_{пр.с}(\varphi)\, d\varphi = -619.908$$

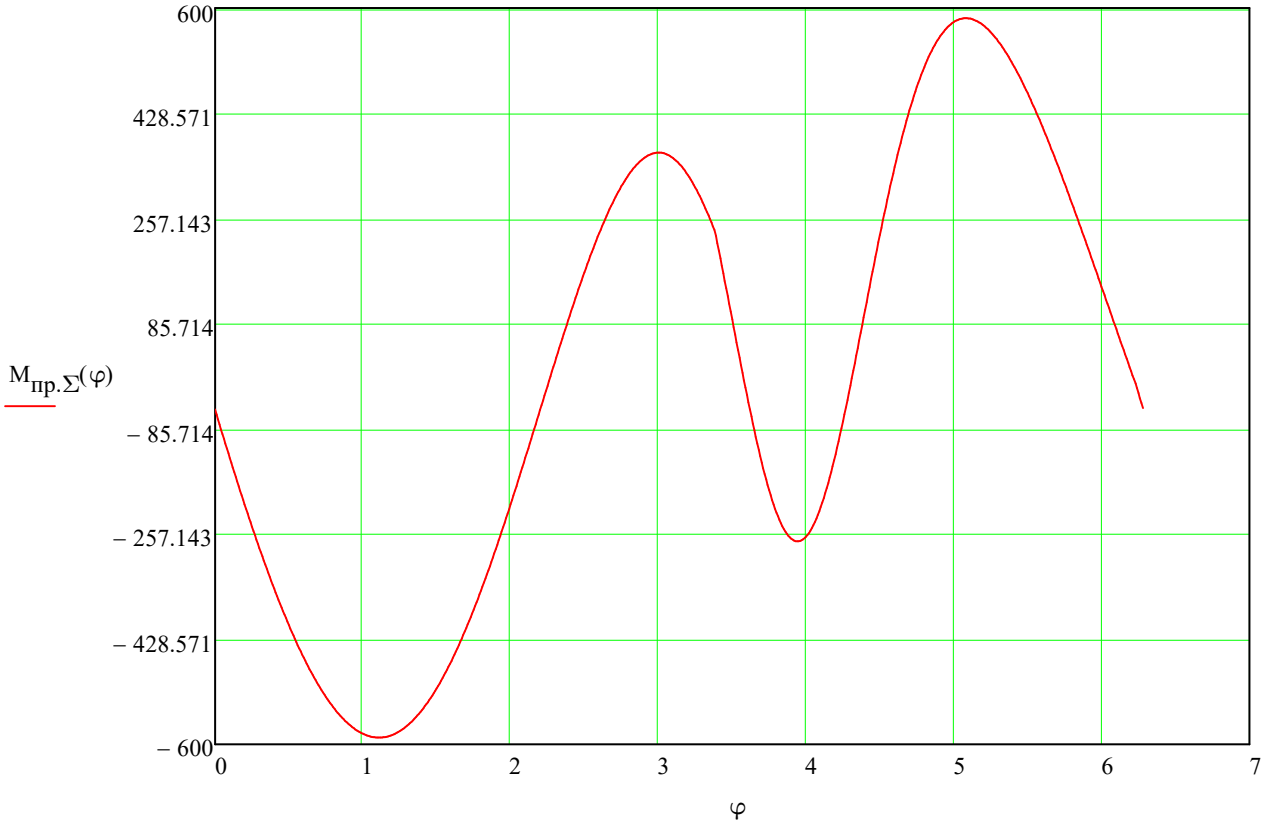
Найдём приведённый движущий момент

$$M_{пр.дв} := \frac{-A_c}{2\pi} = 98.661$$

Вычислим приведённый суммарный момент

$$M_{пр.\Sigma}(\varphi) := M_{пр.дв} + M_{пр.с}(\varphi)$$

$$M_{пр.\Sigma}(f) = -392.833$$



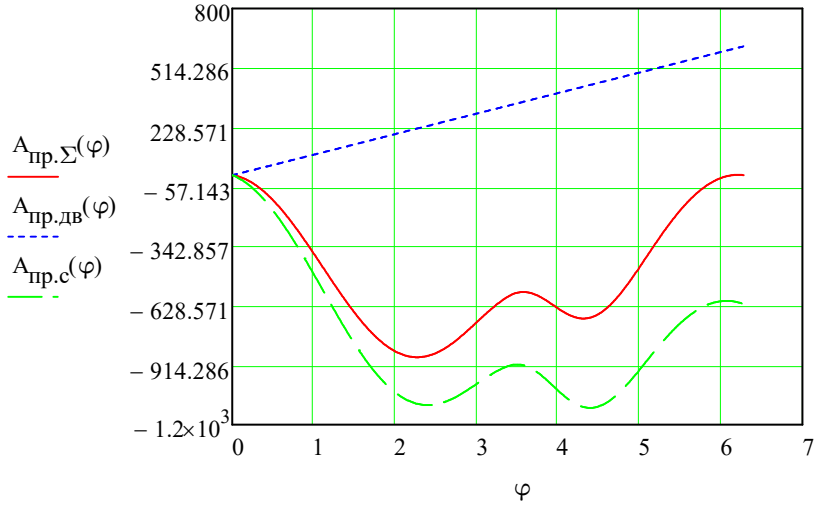
Рассчитаем момент инерции первой группы звеньев
Вычислим работу суммарного момента

$$A_{пр.\Sigma}(\varphi) := \int_0^{\varphi} M_{пр.\Sigma}(\varphi)\, d\varphi \qquad A_{пр.дв}(\varphi) := \int_0^{\varphi} M_{пр.дв}\, d\varphi \qquad A_{пр.с}(\varphi) := \int_0^{\varphi} M_{пр.с}(\varphi)\, d\varphi$$

$$A_{пр.\Sigma 1}(\varphi) := A_{пр.дв}(\varphi) + A_{пр.с}(\varphi)$$

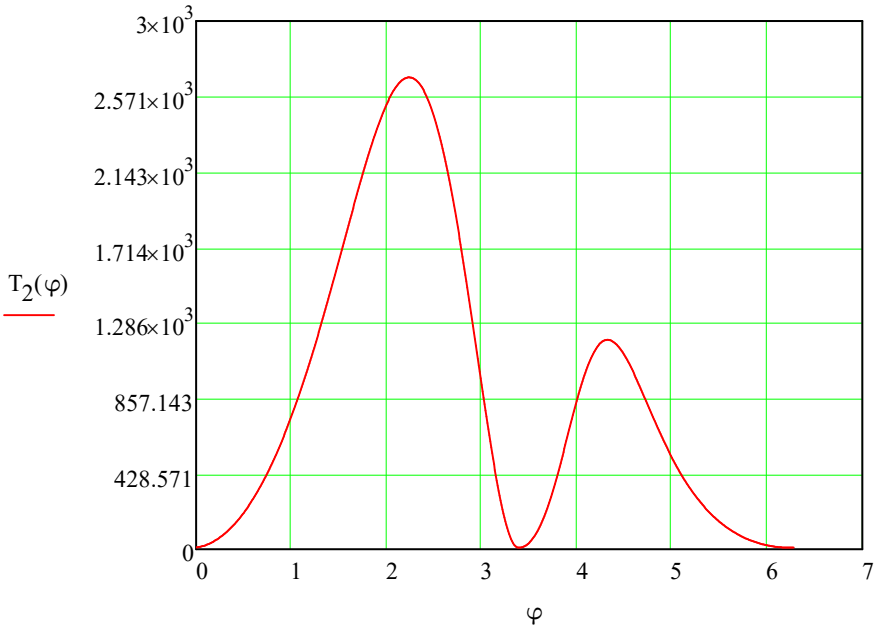
$n_1 := 25$

$$\omega_{1ср} := \frac{n_1 \cdot 2\pi}{60} = 2.618$$



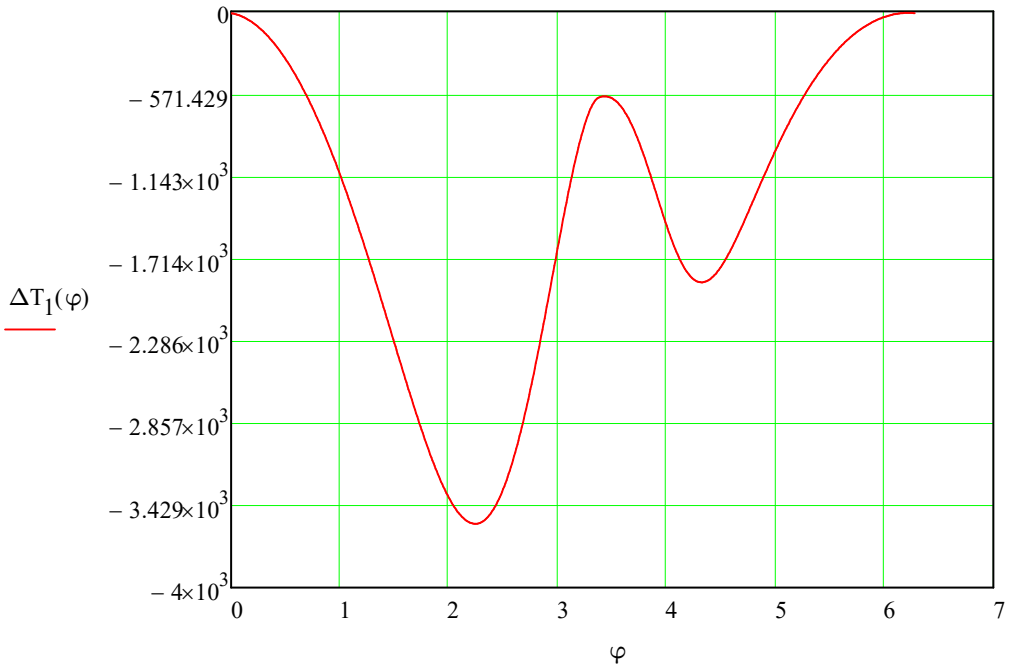
Определим кинетическую энергию второй группы звеньев:

$$T_2(\varphi) := J_{2пр}(\varphi) \cdot \frac{\omega_{1ср}^2}{2}$$



Определим изменение кинетической энергии первой группы звеньев:

$$\Delta T_1(\varphi) := A_{пр.\Sigma}(\varphi) - T_2(\varphi)$$



$f_1 := 0$

$P := \text{Maximize}(\Delta T_1, f_1)$

$T_{1max} := \Delta T_1(P) = -8.429$

$f_2 := 2.2$

$P_1 := \text{Minimize}(\Delta T_1, f_2)$

$T_{1min} := \Delta T_1(P_1) = -3.556 \times 10^3$

$\delta := 0.11$

$\Delta T_{1нб} := T_{1max} - T_{1min} = 3.547 \times 10^3$

$$J_{1пр} := \frac{\Delta T_{1нб}}{\omega_{1ср}^{2} \cdot \delta} = 4.705 \times 10^3$$

необходимый момент инерции маховых масс

График угловой скорости звена приведения:

$$\Delta\omega(\varphi) := \frac{\Delta T_1(\varphi) - \frac{T_{1max} + T_{1min}}{2}}{\omega_{1cp} \cdot J_{1пр}} \qquad \Delta\omega(f) = -0.087$$

$$\omega(\varphi) := \omega_{1cp} + \Delta\omega(\varphi) \qquad \omega(f) = 2.531$$

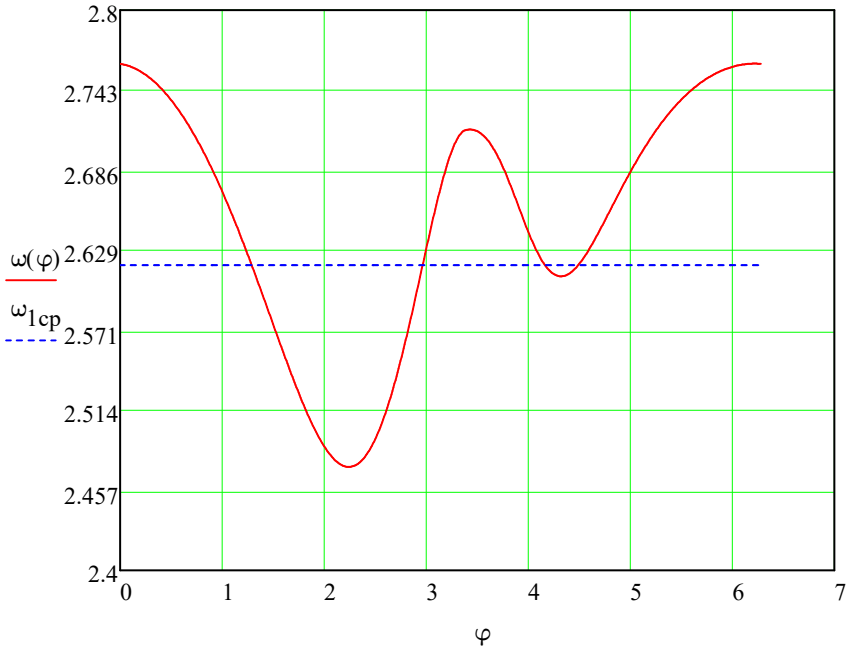
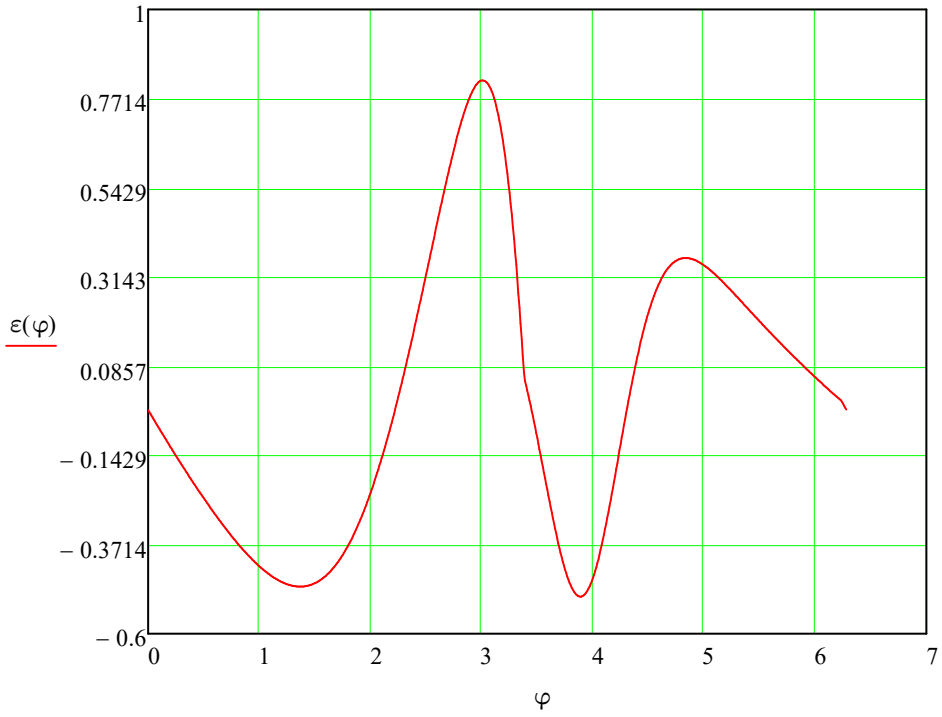


График углового ускорения звена приведения:

$$\varepsilon(\varphi) := \frac{M_{пр.\Sigma}(\varphi)}{J_{2пр}(\varphi) + J_{1пр}} - \frac{\omega(\varphi)^2 \cdot dJ_{2пр}(\varphi)}{2 \cdot \left(J_{2пр}(\varphi) + J_{1пр}\right)} \qquad \varepsilon(f) = -0.406$$



Выбор электродвигателя

Рассчитаем необходимую мощность электродвигателя:

$P_c := M_{пр.дв} \cdot \omega_{1ср}$ $P_c = 258.295$

$\eta := 0.99 \cdot 0.96 \cdot 0.98$ $\eta = 0.931$

$P_D := \frac{P_c}{\eta}$ $P_D = 277.322$

По результатам расчета выбираем электродвигатель **АИР63А4**

$P := 250$ $n := 1500$ $U_{56} := 4$ $n_2 := n_1 \cdot U_{56}$

$n_{ном} := 1350$ $\lambda_{кр} := 2.2$ $U_{д1} := \frac{n}{n_2} = 15$

$\lambda_п := 2.2$

$J_{1пр.н} := J_{1пр} \cdot \left(\frac{1}{U_{56}}\right)^2 = 294.069$

$J_{O.пр} := 0.25 \cdot g = 2.453 \quad кг \cdot м^2$

$J_{доп} := J_{1пр.н} - J_{O.пр} - J_{к5} - J_{к6} - J_{ред} = 289.606 \quad кг \cdot м^2$ Момент инерции дполнительной маховой массы (маховаика)

$\psi_b := 0.2$ $\psi_h := 0.8$ $\rho := 7800 \quad \frac{кг}{м^3}$

Маховик - обход со спицами и ступицей

$D_2 := 0.437\sqrt[5]{J_{доп}} = 1.358$ м

$D_1 := 0.8 D_2 = 1.086$ м

$b := 0.2 D_2 = 0.272$ м

$m_1 := 6123\left(D_2^{\ 2} - D_1^{\ 2}\right) \cdot b = 1.104 \times 10^{\hat{}}$ кг

Маховик - диск

$D := 0.366\sqrt[5]{J_{доп}} = 1.137$ м

$b := 0.2D = 0.227$ м

$m_{12} := 1230 D^3 = 1.809 \times 10^{\hat{}}$ кг

Реальные значения ускорений:

$a_{Bx}(\varphi) := \omega(\varphi)^2 a_{qBx}(\varphi) + \varepsilon(\varphi) \cdot V_{qBx}(\varphi)$ $a_{Bx}(f) = 0.449$

$a_{By}(\varphi) := \omega(\varphi)^2 a_{qBy}(\varphi) + \varepsilon(\varphi) \cdot V_{qBy}(\varphi)$ $a_{By}(f) = -0.927$

$a_B(\varphi) := \sqrt{a_{Bx}(\varphi)^2 + a_{By}(\varphi)^2}$ $a_B(f) = 1.03$

$a_{S2y}(\varphi) := \omega(\varphi)^2 a_{qS2y}(\varphi) + \varepsilon(\varphi) \cdot V_{qS2y}(\varphi)$ $a_{S2y}(f) = -1.461$

$a_{S2x}(\varphi) := \omega(\varphi)^2 a_{qS2x}(\varphi) + \varepsilon(\varphi) \cdot V_{qS2x}(\varphi)$ $a_{S2x}(f) = 0.719$

$a_{S2}(\varphi) := \sqrt{a_{S2x}(\varphi)^2 + a_{S2y}(\varphi)^2}$ $a_{S2}(f) = 1.628$

$a_{Hx}(\varphi) := \omega(\varphi)^2 a_{qHx}(\varphi) + \varepsilon(\varphi) \cdot V_{qHx}(\varphi)$

$a_{Hy}(\varphi) := \omega(\varphi)^2 a_{qHy}(\varphi) + \varepsilon(\varphi) \cdot V_{qHy}(\varphi)$

$a_H(\varphi) := \sqrt{a_{Hx}(\varphi)^2 + a_{Hy}(\varphi)^2}$ $a_H(f) = 1.845$

$a_{S4x}(\varphi) := \omega(\varphi)^2 a_{qS4x}(\varphi) + \varepsilon(\varphi) \cdot V_{qS4x}(\varphi)$

$a_{S4y}(\varphi) := \omega(\varphi)^2 a_{qS4y}(\varphi) + \varepsilon(\varphi) \cdot V_{qS4y}(\varphi)$

$a_{S4}(\varphi) := \sqrt{a_{S4x}(\varphi)^2 + a_{S4y}(\varphi)^2}$ $a_{S4}(f) = 1.655$

$\varepsilon_1(\varphi) := \omega(\varphi)^2 \cdot \varepsilon_{q1}(\varphi) + \varepsilon(\varphi) \cdot \omega_{q1}(\varphi)$ $\varepsilon_1(f) = 0.406$

$\varepsilon_2(\varphi) := \omega(\varphi)^2 \cdot \varepsilon_{q2}(\varphi) + \varepsilon(\varphi) \cdot \omega_{q2}(\varphi)$ $\varepsilon_2(f) = 0.826$

$\varepsilon_3(\varphi) := \omega(\varphi)^2 \cdot \varepsilon_{q3}(\varphi) + \varepsilon(\varphi) \cdot \omega_{q3}(\varphi)$ $\varepsilon_3(f) = -0.416$

$\varepsilon_4(\varphi) := \omega(\varphi)^2 \cdot \varepsilon_{q4}(\varphi) + \varepsilon(\varphi) \cdot \omega_{q4}(\varphi)$ $\varepsilon_4(f) = 1.225$

Силовой расчет

	$O_{1в}$	$A_{1в}$	$B_{1в}$	$C_{1в}$	$D_{1в}$	$H_{1в}$	$H_{1п}$
1	1	1	0	0	0	0	0
2	0	–1	1	0	0	0	0
3	0	0	–1	1	1	0	0
4	0	0	0	0	–1	1	0
5	0	0	0	0	0	–1	1
0	–1	0	0	–1	0	0	–1

Инерционная нагрузка и силы тяжести:

Звено 1

$\Phi_{1x}(\varphi) := 0$

$\Phi_{1y}(\varphi) := 0$

$G_{1y} := 0$

$M_{\Phi 1}(\varphi) := -J_{1пр} \varepsilon_1(\varphi)$ $M_{\Phi 1}(f) = -1.911 \times 10^3$

Звено 2

$\Phi_{2x}(\varphi) := -m_2 \cdot a_{S2x}(\varphi)$ $\Phi_{2x}(f) = -64.696$

$\Phi_{2y}(\varphi) := -m_2 \cdot a_{S2y}(\varphi)$ $\Phi_{2y}(f) = 131.513$

$G_{2y} := -G_2$

$M_{\Phi 2}(\varphi) := -J_{S2} \cdot \varepsilon_2(\varphi)$ $M_{\Phi 2}(f) = -3.644$

Звено 3

$\Phi_{3x}(\varphi) := -m_3 \cdot a_{Bx}(\varphi)$ $\Phi_{3x}(f) = -71.764$

$\Phi_{3y}(\varphi) := -m_3 \cdot a_{By}(\varphi)$ $\Phi_{3y}(f) = 148.37$

$G_{3y} := -G_3$

$M_{\Phi 3}(\varphi) := -J_{S3} \cdot \varepsilon_3(\varphi)$ $M_{\Phi 3}(f) = 2.242$

Звено 4

$\Phi_{4x}(\varphi) := -m_4 \cdot a_{S4x}(\varphi)$ $\Phi_{4x}(f) = -301.572$

$\Phi_{4y}(\varphi) := -m_4 \cdot a_{S4y}(\varphi)$ $\Phi_{4y}(f) = 204.009$

$G_{4y} := -G_4$

$M_{\Phi 4}(\varphi) := -J_{S4} \cdot \varepsilon_4(\varphi)$ $M_{\Phi 4}(f) = -19.348$

Звено 5

$\Phi_{5x}(\varphi) := -m_5(\varphi) \cdot a_{Hx}(\varphi)$ $\Phi_{5x}(f) = -1.909 \times 10^3$

$\Phi_{5y}(\varphi) := 0$

$G_{5y}(\varphi) := -G_5(\varphi)$

$M_{\Phi 5}(\varphi) := 0$

$$A_{11} := \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 1 \end{pmatrix} \quad A_{12} := \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad A_{13} := \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{pmatrix}$$

$A_1 := \text{augment}(A_{11}, A_{12}, A_{13}) =$

	0	1	2	3	4	5	6	7	8	9
0	1	1	0	0	0	0	0	0	0	0
1	0	-1	1	0	0	0	0	0	0	0
2	0	0	-1	1	1	0	0	0	0	0
3	0	0	0	0	-1	1	0	0	0	0
4	0	0	0	0	0	-1	1	0	0	...

$$A_2 := \text{augment}(A_{12}, A_{11}, A_{13}) = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 \end{pmatrix}$$

$Y1(\varphi) := \begin{pmatrix} 0 & Y_A(\varphi) & Y_B(\varphi) & 0 & Y_D(\varphi) & Y_H & Y_H \end{pmatrix}$

$Y1(f) = (0 \quad 0.301 \quad 0.846 \quad 0 \quad 1.691 \quad 0.9 \quad 0.9)$

$$YY(\varphi) := \text{stack}(Y1(\varphi), Y1(\varphi), Y1(\varphi), Y1(\varphi), Y1(\varphi)) \quad YY(f) = \begin{pmatrix} 0 & 0.301 & 0.846 & 0 & 1.691 & 0.9 & 0.9 \\ 0 & 0.301 & 0.846 & 0 & 1.691 & 0.9 & 0.9 \\ 0 & 0.301 & 0.846 & 0 & 1.691 & 0.9 & 0.9 \\ 0 & 0.301 & 0.846 & 0 & 1.691 & 0.9 & 0.9 \\ 0 & 0.301 & 0.846 & 0 & 1.691 & 0.9 & 0.9 \end{pmatrix}$$

$$A_{31}(\varphi) := \overrightarrow{\left(-A_{11}\, YY(\varphi)\right)} \qquad A_{31}(f) = \begin{pmatrix} 0 & -0.301 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.301 & -0.846 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.846 & 0 & -1.691 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.691 & -0.9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.9 & -0.9 \end{pmatrix}$$

$$X1(\varphi) := \begin{pmatrix} 0 & X_A(\varphi) & X_B(\varphi) & X_C & X_D(\varphi) & X_H(\varphi) & X_H(\varphi) \end{pmatrix}$$

$$X1(f) = (0 \quad -0.174 \quad 1.165 \quad 1.25 \quad 1.079 \quad 2.584 \quad 2.584)$$

$$XX(\varphi) := \text{stack}(X1(\varphi), X1(\varphi), X1(\varphi), X1(\varphi), X1(\varphi)) \qquad XX(f) = \begin{pmatrix} 0 & -0.174 & 1.165 & 1.25 & 1.079 & 2.584 & 2.584 \\ 0 & -0.174 & 1.165 & 1.25 & 1.079 & 2.584 & 2.584 \\ 0 & -0.174 & 1.165 & 1.25 & 1.079 & 2.584 & 2.584 \\ 0 & -0.174 & 1.165 & 1.25 & 1.079 & 2.584 & 2.584 \\ 0 & -0.174 & 1.165 & 1.25 & 1.079 & 2.584 & 2.584 \end{pmatrix}$$

$$A_{32}(\varphi) := \overrightarrow{\left(A_{11}\, XX(\varphi)\right)}$$

$$A_{33} := \begin{pmatrix} 0 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 1 & 0 \end{pmatrix} \qquad A_{32}(f) = \begin{pmatrix} 0 & -0.174 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.174 & 1.165 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1.165 & 1.25 & 1.079 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1.079 & 2.584 & 0 \\ 0 & 0 & 0 & 0 & 0 & -2.584 & 2.584 \end{pmatrix}$$

$$A_3(\varphi) := \text{augment}\left(A_{31}(\varphi), A_{32}(\varphi), A_{33}\right)$$

$A_3(f) =$

	0	1	2	3	4	5	6	7
0	0	-0.301	0	0	0	0	0	0
1	0	0.301	-0.846	0	0	0	0	0
2	0	0	0.846	0	-1.691	0	0	0
3	0	0	0	0	1.691	-0.9	0	0
4	0	0	0	0	0	0.9	-0.9	...

$$A_{41} := (0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad -1)$$

$$A_{42} := (0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0)$$

$$A_{43} := (0 \quad 0)$$

$A_4 := \text{augment}\left(A_{41}, A_{42}, A_{43}\right) =$

	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	-1	0	0	...

$$A1(\varphi) := \text{stack}\left(A_1, A_2, A_3(\varphi), A_4\right)$$

$$\text{rows}(A1(f)) = 16 \qquad \text{cols}(A1(f)) = 16$$

$A1(f) =$

	0	1	2	3	4	5	6	7
0	1	1	0	0	0	0	0	0
1	0	-1	1	0	0	0	0	0
2	0	0	-1	1	1	0	0	0
3	0	0	0	0	-1	1	0	0
4	0	0	0	0	0	-1	1	0
5	0	0	0	0	0	0	0	1
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	-0.301	0	0	0	0	0	0
11	0	0.301	-0.846	0	0	0	0	0
12	0	0	0.846	0	-1.691	0	0	0
13	0	0	0	0	1.691	-0.9	0	0
14	0	0	0	0	0	0.9	-0.9	0
15	0	0	0	0	0	0	-1	...

$$B_1(\varphi) := -\begin{pmatrix} 0 \\ \Phi_{2x}(\varphi)\cdot 1 \\ \Phi_{3x}(\varphi)\cdot 1 \\ \Phi_{4x}(\varphi)\cdot 1 \\ \Phi_{5x}(\varphi)\cdot 1 + F_{\text{сопр}}(\varphi)\cdot 1 \end{pmatrix} \qquad B_1(f) = \begin{pmatrix} 0 \\ 64.696 \\ 71.764 \\ 301.572 \\ 2.301 \times 10^3 \end{pmatrix}$$

$$B_2(\varphi) := -\begin{pmatrix} 0 \\ \Phi_{2y}(\varphi)\cdot 1 + G_{2y}\cdot 1 \\ \Phi_{3y}(\varphi)\cdot 1 + G_{3y}\cdot 1 \\ \Phi_{4y}(\varphi)\cdot 1 + G_{4y}\cdot 1 \\ G_{5y}(\varphi)\cdot 1 \end{pmatrix} \qquad B_2(f) = \begin{pmatrix} 0 \\ 751.387 \\ 1.421 \times 10^3 \\ 1.954 \times 10^3 \\ 1.015 \times 10^4 \end{pmatrix}$$

$$B_3(\varphi) := -\begin{pmatrix} M_{\Phi 1}(\varphi)\cdot 1 \\ M_{\Phi 2}(\varphi)\cdot 1 + G_{2y}\cdot X_{S2}(\varphi)\cdot 1 - \Phi_{2x}(\varphi)\cdot Y_{S2}(\varphi)\cdot 1 + \Phi_{2y}(\varphi)\cdot X_{S2}(\varphi)\cdot 1 \\ M_{\Phi 3}(\varphi)\cdot 1 + G_{3y}\cdot X_B(\varphi)\cdot 1 - \Phi_{3x}(\varphi)\cdot Y_B(\varphi)\cdot 1 + \Phi_{3y}(\varphi)\cdot X_B(\varphi)\cdot 1 \\ M_{\Phi 4}(\varphi)\cdot 1 + G_{4y}\cdot X_{S4}(\varphi)\cdot 1 - \Phi_{4x}(\varphi)\cdot Y_{S4}(\varphi)\cdot 1 + \Phi_{4y}(\varphi)\cdot X_{S4}(\varphi)\cdot 1 \\ G_{5y}(\varphi)\cdot X_H(\varphi)\cdot 1 - \Phi_{5x}(\varphi)\cdot Y_H\cdot 1 - F_{\text{сопр}}(f)\cdot Y_H\cdot 1 \end{pmatrix} \qquad B_3(f) = \begin{pmatrix} 1.911 \times 10^3 \\ 338.954 \\ 1.592 \times 10^3 \\ 3.208 \times 10^3 \\ 2.416 \times 10^4 \end{pmatrix}$$

$$B_4 := (0) \qquad B(\varphi) := \text{stack}\left(B_1(\varphi), B_2(\varphi), B_3(\varphi), B_4\right)$$

$$D1(\varphi) := \text{lsolve}(A1(\varphi), B(\varphi)) \qquad \text{rows}(B(f)) = 16 \qquad \text{cols}(B(f)) = 1$$

$D1(f) =$

	0
0	$5.247 \cdot 10^3$
1	$-5.247 \cdot 10^3$
2	$-5.182 \cdot 10^3$
3	$-2.507 \cdot 10^3$
4	$-2.603 \cdot 10^3$
5	$-2.301 \cdot 10^3$
6	0
7	$2.497 \cdot 10^3$
8	$-2.497 \cdot 10^3$
9	$-1.746 \cdot 10^3$
10	-650.445
11	325.693
12	$2.28 \cdot 10^3$
13	$1.243 \cdot 10^4$
14	0
15	-98.661

$F_{10x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 0 \rangle}$ $F_{10x}(f) = \left(5.247 \times 10^3\right)$

$F_{12x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 1 \rangle}$ $F_{12x}(f) = \left(-5.247 \times 10^3\right)$

$F_{23x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 2 \rangle}$ $F_{23x}(f) = \left(-5.182 \times 10^3\right)$

$F_{30x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 3 \rangle}$ $F_{30x}(f) = \left(-2.507 \times 10^3\right)$

$F_{34x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 4 \rangle}$ $F_{34x}(f) = \left(-2.603 \times 10^3\right)$

$F_{45x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 5 \rangle}$ $F_{45x}(f) = \left(-2.301 \times 10^3\right)$

$F_{50x}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 6 \rangle}$ $F_{50x}(f) = (0)$

$F_{10y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 7 \rangle}$ $F_{10y}(f) = \left(2.497 \times 10^3\right)$

$F_{12y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 8 \rangle}$ $F_{12y}(f) = \left(-2.497 \times 10^3\right)$

$F_{23y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 9 \rangle}$ $F_{23y}(f) = \left(-1.746 \times 10^3\right)$

$F_{30y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 10 \rangle}$ $F_{30y}(f) = (-650.445)$

$F_{34y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 11 \rangle}$ $F_{34y}(f) = (325.693)$

$F_{45y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 12 \rangle}$ $F_{45y}(f) = \left(2.28 \times 10^3\right)$

$F_{50y}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 13 \rangle}$ $F_{50y}(f) = \left(1.243 \times 10^4\right)$

$M_{50}(\varphi) := \left(D1(\varphi)^T\right)^{\langle 14 \rangle}$ $M_{50}(f) = (0)$

$M_1(\varphi) := \left(D1(\varphi)^T\right)^{\langle 15 \rangle}$ $M_1(f) = (-98.661)$

$B(f) =$

	0
0	0
1	64.696
2	71.764
3	301.572
4	$2.301 \cdot 10^3$
5	0
6	751.387
7	$1.421 \cdot 10^3$
8	$1.954 \cdot 10^3$
9	$1.015 \cdot 10^4$
10	$1.911 \cdot 10^3$
11	338.954
12	$1.592 \cdot 10^3$
13	$3.208 \cdot 10^3$
14	$2.416 \cdot 10^4$
15	0

$G_t := 270000000\ \text{Па}$ Предел текучески при изгибе Ст5

$\rho := 7850\ \frac{\text{кг}}{\text{м}^3}$

Для звена 4:

$F_{45x}(10\text{deg})\cdot\sin(\delta_3(10\text{deg})) + F_{45y}(10\text{deg})\cdot\cos(\delta_3(10\text{deg})) \ldots = (7.844)$
$+ 0.5(-G_4\cdot\cos(\delta_3(10\text{deg})) + \Phi_{4x}(10\text{deg})\cdot\sin(\delta_3(10\text{deg})) + \Phi_{4y}(10\text{deg})\cdot\cos(\delta_3(10\text{deg}))) + M_{\Phi4}(10\text{deg})$

$x_1 := 7.844$

$F_{45x}(10\text{deg})\cdot\cos(\delta_3(10\text{deg})) - F_{45y}(10\text{deg})\cdot\sin(\delta_3(10\text{deg})) \ldots = (-3.709\times 10^3)$
$+ G_4\cdot\sin(\delta_3(10\text{deg})) + \Phi_{4x}(10\text{deg})\cdot\cos(\delta_3(10\text{deg})) - \Phi_{4y}(10\text{deg})\cdot\sin(\delta_3(10\text{deg}))$

$x_{1a} := -3709$

$F_{45x}(20\text{deg})\cdot\sin(\delta_3(20\text{deg})) + F_{45y}(20\text{deg})\cdot\cos(\delta_3(20\text{deg})) \ldots = (6.893)$
$+ 0.5(-G_4\cdot\cos(\delta_3(20\text{deg})) + \Phi_{4x}(20\text{deg})\cdot\sin(\delta_3(20\text{deg})) + \Phi_{4y}(20\text{deg})\cdot\cos(\delta_3(20\text{deg}))) + M_{\Phi4}(20\text{deg})$

$x_2 := 6.893$

$F_{45x}(20\text{deg})\cdot\cos(\delta_3(20\text{deg})) - F_{45y}(20\text{deg})\cdot\sin(\delta_3(20\text{deg})) \ldots = (-3.693\times 10^3)$
$+ G_4\cdot\sin(\delta_3(20\text{deg})) + \Phi_{4x}(20\text{deg})\cdot\cos(\delta_3(20\text{deg})) - \Phi_{4y}(20\text{deg})\cdot\sin(\delta_3(20\text{deg}))$

$x_{2a} := -3693$

$F_{45x}(30\text{deg})\cdot\sin(\delta_3(30\text{deg})) + F_{45y}(30\text{deg})\cdot\cos(\delta_3(30\text{deg})) \ldots = (5.523)$
$+ 0.5\cdot(-G_4\cdot\cos(\delta_3(30\text{deg})) + \Phi_{4x}(30\text{deg})\cdot\sin(\delta_3(30\text{deg})) + \Phi_{4y}(30\text{deg})\cdot\cos(\delta_3(30\text{deg}))) + M_{\Phi4}(30\text{deg})$

$x_3 := 5.523$

$F_{45x}(30\text{deg})\cdot\cos(\delta_3(30\text{deg})) - F_{45y}(30\text{deg})\cdot\sin(\delta_3(30\text{deg})) \ldots = (-3.695\times 10^3)$
$+ G_4\cdot\sin(\delta_3(30\text{deg})) + \Phi_{4x}(30\text{deg})\cdot\cos(\delta_3(30\text{deg})) - \Phi_{4y}(30\text{deg})\cdot\sin(\delta_3(30\text{deg}))$

$x_{3a} := -3695$

$F_{45x}(40\text{deg})\cdot\sin(\delta_3(40\text{deg})) + F_{45y}(40\text{deg})\cdot\cos(\delta_3(40\text{deg})) \ldots = (3.765)$
$+ 0.5\cdot(-G_4\cdot\cos(\delta_3(40\text{deg})) + \Phi_{4x}(40\text{deg})\cdot\sin(\delta_3(40\text{deg})) + \Phi_{4y}(40\text{deg})\cdot\cos(\delta_3(40\text{deg}))) + M_{\Phi4}(40\text{deg})$

$x_4 := 3.765$

$F_{45x}(40\text{deg})\cdot\cos(\delta_3(40\text{deg})) - F_{45y}(40\text{deg})\cdot\sin(\delta_3(40\text{deg})) \ldots = (-3.695\times 10^3)$
$+ G_4\cdot\sin(\delta_3(40\text{deg})) + \Phi_{4x}(40\text{deg})\cdot\cos(\delta_3(40\text{deg})) - \Phi_{4y}(40\text{deg})\cdot\sin(\delta_3(40\text{deg}))$

$x_{4a} := -3695$

$F_{45x}(50\text{deg})\cdot\sin(\delta_3(50\text{deg})) + F_{45y}(50\text{deg})\cdot\cos(\delta_3(50\text{deg})) \ldots = (1.69)$
$+ 0.5\cdot(-G_4\cdot\cos(\delta_3(50\text{deg})) + \Phi_{4x}(50\text{deg})\cdot\sin(\delta_3(50\text{deg})) + \Phi_{4y}(50\text{deg})\cdot\cos(\delta_3(50\text{deg}))) + M_{\Phi4}(50\text{deg})$

$x_5 := 1.69$

$F_{45x}(50\text{deg})\cdot\cos(\delta_3(50\text{deg})) - F_{45y}(50\text{deg})\cdot\sin(\delta_3(50\text{deg})) \ldots = (-3.676\times 10^3)$
$+ G_4\cdot\sin(\delta_3(50\text{deg})) + \Phi_{4x}(50\text{deg})\cdot\cos(\delta_3(50\text{deg})) - \Phi_{4y}(50\text{deg})\cdot\sin(\delta_3(50\text{deg}))$

$x_{5a} := -3676$

$F_{45x}(60\text{deg})\cdot\sin(\delta_3(60\text{deg})) + F_{45y}(60\text{deg})\cdot\cos(\delta_3(60\text{deg})) \ldots = (-0.58)$
$+ 0.5\cdot(-G_4\cdot\cos(\delta_3(60\text{deg})) + \Phi_{4x}(60\text{deg})\cdot\sin(\delta_3(60\text{deg})) + \Phi_{4y}(60\text{deg})\cdot\cos(\delta_3(60\text{deg}))) + M_{\Phi4}(60\text{deg})$

$x_6 := -0.58$

$F_{45x}(60\text{deg})\cdot\cos(\delta_3(60\text{deg})) - F_{45y}(60\text{deg})\cdot\sin(\delta_3(60\text{deg})) \ldots = (-3.615\times 10^3)$
$+ G_4\cdot\sin(\delta_3(60\text{deg})) + \Phi_{4x}(60\text{deg})\cdot\cos(\delta_3(60\text{deg})) - \Phi_{4y}(60\text{deg})\cdot\sin(\delta_3(60\text{deg}))$

$x_{6a} := -3615$

$F_{45x}(70deg)\cdot\sin\left(\delta_3(70deg)\right) + F_{45y}(70deg)\cdot\cos\left(\delta_3(70deg)\right) \ldots = (-2.881)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(70deg)\right) + \Phi_{4x}(70deg)\cdot\sin\left(\delta_3(70deg)\right) + \Phi_{4y}(70deg)\cdot\cos\left(\delta_3(70deg)\right)\right) + M_{\Phi 4}(70deg)$

$x_7 := -2.881$

$F_{45x}(70deg)\cdot\cos\left(\delta_3(70deg)\right) - F_{45y}(70deg)\cdot\sin\left(\delta_3(70deg)\right) \ldots = \left(-3.487\times 10^3\right)$
$+ G_4\cdot\sin\left(\delta_3(70deg)\right) + \Phi_{4x}(70deg)\cdot\cos\left(\delta_3(70deg)\right) - \Phi_{4y}(70deg)\cdot\sin\left(\delta_3(70deg)\right)$

$x_{7a} := -3487$

$F_{45x}(80deg)\cdot\sin\left(\delta_3(80deg)\right) + F_{45y}(80deg)\cdot\cos\left(\delta_3(80deg)\right) \ldots = (-5.02)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(80deg)\right) + \Phi_{4x}(80deg)\cdot\sin\left(\delta_3(80deg)\right) + \Phi_{4y}(80deg)\cdot\cos\left(\delta_3(80deg)\right)\right) + M_{\Phi 4}(80deg)$

$x_8 := -5.02$

$F_{45x}(80deg)\cdot\cos\left(\delta_3(80deg)\right) - F_{45y}(80deg)\cdot\sin\left(\delta_3(80deg)\right) \ldots = \left(-3.261\times 10^3\right)$
$+ G_4\cdot\sin\left(\delta_3(80deg)\right) + \Phi_{4x}(80deg)\cdot\cos\left(\delta_3(80deg)\right) - \Phi_{4y}(80deg)\cdot\sin\left(\delta_3(80deg)\right)$

$x_{8a} := -3261$

$F_{45x}(90deg)\cdot\sin\left(\delta_3(90deg)\right) + F_{45y}(90deg)\cdot\cos\left(\delta_3(90deg)\right) \ldots = (-6.801)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(90deg)\right) + \Phi_{4x}(90deg)\cdot\sin\left(\delta_3(90deg)\right) + \Phi_{4y}(90deg)\cdot\cos\left(\delta_3(90deg)\right)\right) + M_{\Phi 4}(90deg)$

$x_9 := -6.801$

$F_{45x}(90deg)\cdot\cos\left(\delta_3(90deg)\right) - F_{45y}(90deg)\cdot\sin\left(\delta_3(90deg)\right) \ldots = \left(-2.909\times 10^3\right)$
$+ G_4\cdot\sin\left(\delta_3(90deg)\right) + \Phi_{4x}(90deg)\cdot\cos\left(\delta_3(90deg)\right) - \Phi_{4y}(90deg)\cdot\sin\left(\delta_3(90deg)\right)$

$x_{9a} := -2909$

$F_{45x}(100deg)\cdot\sin\left(\delta_3(100deg)\right) + F_{45y}(100deg)\cdot\cos\left(\delta_3(100deg)\right) \ldots = (-8.054)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(100deg)\right) + \Phi_{4x}(100deg)\cdot\sin\left(\delta_3(100deg)\right) + \Phi_{4y}(100deg)\cdot\cos\left(\delta_3(100deg)\right)\right) + M_{\Phi 4}(100deg)$

$x_{10} := -8.054$

$F_{45x}(100deg)\cdot\cos\left(\delta_3(100deg)\right) - F_{45y}(100deg)\cdot\sin\left(\delta_3(100deg)\right) \ldots = \left(-2.403\times 10^3\right)$
$+ G_4\cdot\sin\left(\delta_3(100deg)\right) + \Phi_{4x}(100deg)\cdot\cos\left(\delta_3(100deg)\right) - \Phi_{4y}(100deg)\cdot\sin\left(\delta_3(100deg)\right)$

$x_{10a} := -2403$

$F_{45x}(110deg)\cdot\sin\left(\delta_3(110deg)\right) + F_{45y}(110deg)\cdot\cos\left(\delta_3(110deg)\right) \ldots = (-8.664)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(110deg)\right) + \Phi_{4x}(110deg)\cdot\sin\left(\delta_3(110deg)\right) + \Phi_{4y}(110deg)\cdot\cos\left(\delta_3(110deg)\right)\right) + M_{\Phi 4}(110deg)$

$x_{11} := -8.664$

$F_{45x}(110deg)\cdot\cos\left(\delta_3(110deg)\right) - F_{45y}(110deg)\cdot\sin\left(\delta_3(110deg)\right) \ldots = \left(-1.728\times 10^3\right)$
$+ G_4\cdot\sin\left(\delta_3(110deg)\right) + \Phi_{4x}(110deg)\cdot\cos\left(\delta_3(110deg)\right) - \Phi_{4y}(110deg)\cdot\sin\left(\delta_3(110deg)\right)$

$x_{11a} := -1728$

$F_{45x}(120deg)\cdot\sin\left(\delta_3(120deg)\right) + F_{45y}(120deg)\cdot\cos\left(\delta_3(120deg)\right) \ldots = (-8.574)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(120deg)\right) + \Phi_{4x}(120deg)\cdot\sin\left(\delta_3(120deg)\right) + \Phi_{4y}(120deg)\cdot\cos\left(\delta_3(120deg)\right)\right) + M_{\Phi 4}(120deg)$

$x_{12} := -8.574$

$F_{45x}(120deg)\cdot\cos\left(\delta_3(120deg)\right) - F_{45y}(120deg)\cdot\sin\left(\delta_3(120deg)\right) \ldots = (-872.448)$
$+ G_4\cdot\sin\left(\delta_3(120deg)\right) + \Phi_{4x}(120deg)\cdot\cos\left(\delta_3(120deg)\right) - \Phi_{4y}(120deg)\cdot\sin\left(\delta_3(120deg)\right)$

$x_{12a} := -872.448$

$F_{45x}(130deg)\cdot\sin\left(\delta_3(130deg)\right) + F_{45y}(130deg)\cdot\cos\left(\delta_3(130deg)\right) \ldots = (-7.757)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(130deg)\right) + \Phi_{4x}(130deg)\cdot\sin\left(\delta_3(130deg)\right) + \Phi_{4y}(130deg)\cdot\cos\left(\delta_3(130deg)\right)\right) + M_{\Phi 4}(130deg)$

$x_{13} := -7.757$

$$F_{45x}(130deg)\cdot\cos\left(\delta_3(130deg)\right) - F_{45y}(130deg)\cdot\sin\left(\delta_3(130deg)\right) \ldots = (178.413)$$
$$+ G_4\cdot\sin\left(\delta_3(130deg)\right) + \Phi_{4x}(130deg)\cdot\cos\left(\delta_3(130deg)\right) - \Phi_{4y}(130deg)\cdot\sin\left(\delta_3(130deg)\right)$$

$x_{13a} := 178.413$

$$F_{45x}(140deg)\cdot\sin\left(\delta_3(140deg)\right) + F_{45y}(140deg)\cdot\cos\left(\delta_3(140deg)\right) \ldots = (-6.159)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(140deg)\right) + \Phi_{4x}(140deg)\cdot\sin\left(\delta_3(140deg)\right) + \Phi_{4y}(140deg)\cdot\cos\left(\delta_3(140deg)\right)\right) + M_{\Phi4}(140deg)$$

$x_{14} := -6.159$

$$F_{45x}(140deg)\cdot\cos\left(\delta_3(140deg)\right) - F_{45y}(140deg)\cdot\sin\left(\delta_3(140deg)\right) \ldots = \left(1.459\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(140deg)\right) + \Phi_{4x}(140deg)\cdot\cos\left(\delta_3(140deg)\right) - \Phi_{4y}(140deg)\cdot\sin\left(\delta_3(140deg)\right)$$

$x_{14a} := 1459$

$$F_{45x}(150deg)\cdot\sin\left(\delta_3(150deg)\right) + F_{45y}(150deg)\cdot\cos\left(\delta_3(150deg)\right) \ldots = (-3.641)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(150deg)\right) + \Phi_{4x}(150deg)\cdot\sin\left(\delta_3(150deg)\right) + \Phi_{4y}(150deg)\cdot\cos\left(\delta_3(150deg)\right)\right) + M_{\Phi4}(150deg)$$

$x_{15} := -3.641$

$$F_{45x}(150deg)\cdot\cos\left(\delta_3(150deg)\right) - F_{45y}(150deg)\cdot\sin\left(\delta_3(150deg)\right) \ldots = \left(3.034\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(150deg)\right) + \Phi_{4x}(150deg)\cdot\cos\left(\delta_3(150deg)\right) - \Phi_{4y}(150deg)\cdot\sin\left(\delta_3(150deg)\right)$$

$x_{15a} := 3034$

$$F_{45x}(160deg)\cdot\sin\left(\delta_3(160deg)\right) + F_{45y}(160deg)\cdot\cos\left(\delta_3(160deg)\right) \ldots = (0.025)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(160deg)\right) + \Phi_{4x}(160deg)\cdot\sin\left(\delta_3(160deg)\right) + \Phi_{4y}(160deg)\cdot\cos\left(\delta_3(160deg)\right)\right) + M_{\Phi4}(160deg)$$

$x_{16} := 0.025$

$$F_{45x}(160deg)\cdot\cos\left(\delta_3(160deg)\right) - F_{45y}(160deg)\cdot\sin\left(\delta_3(160deg)\right) \ldots = \left(4.999\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(160deg)\right) + \Phi_{4x}(160deg)\cdot\cos\left(\delta_3(160deg)\right) - \Phi_{4y}(160deg)\cdot\sin\left(\delta_3(160deg)\right)$$

$x_{16a} := 4999$

$$F_{45x}(170deg)\cdot\sin\left(\delta_3(170deg)\right) + F_{45y}(170deg)\cdot\cos\left(\delta_3(170deg)\right) \ldots = (5.016)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(170deg)\right) + \Phi_{4x}(170deg)\cdot\sin\left(\delta_3(170deg)\right) + \Phi_{4y}(170deg)\cdot\cos\left(\delta_3(170deg)\right)\right) + M_{\Phi4}(170deg)$$

$x_{17} := 5.016$

$$F_{45x}(170deg)\cdot\cos\left(\delta_3(170deg)\right) - F_{45y}(10deg)\cdot\sin\left(\delta_3(170deg)\right) \ldots = \left(5.92\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(170deg)\right) + \Phi_{4x}(170deg)\cdot\cos\left(\delta_3(170deg)\right) - \Phi_{4y}(170deg)\cdot\sin\left(\delta_3(170deg)\right)$$

$x_{17a} := 5920$

$$F_{45x}(180deg)\cdot\sin\left(\delta_3(180deg)\right) + F_{45y}(180deg)\cdot\cos\left(\delta_3(180deg)\right) \ldots = (11.059)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(180deg)\right) + \Phi_{4x}(180deg)\cdot\sin\left(\delta_3(180deg)\right) + \Phi_{4y}(180deg)\cdot\cos\left(\delta_3(180deg)\right)\right) + M_{\Phi4}(180deg)$$

$x_{18} := 11.059$

$$F_{45x}(180deg)\cdot\cos\left(\delta_3(180deg)\right) - F_{45y}(180deg)\cdot\sin\left(\delta_3(180deg)\right) \ldots = \left(1.037\times 10^4\right)$$
$$+ G_4\cdot\sin\left(\delta_3(180deg)\right) + \Phi_{4x}(180deg)\cdot\cos\left(\delta_3(180deg)\right) - \Phi_{4y}(180deg)\cdot\sin\left(\delta_3(180deg)\right)$$

$x_{18a} := 10370$

$$F_{45x}(190deg)\cdot\sin\left(\delta_3(190deg)\right) + F_{45y}(190deg)\cdot\cos\left(\delta_3(190deg)\right) \ldots = (16.697)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(190deg)\right) + \Phi_{4x}(190deg)\cdot\sin\left(\delta_3(190deg)\right) + \Phi_{4y}(190deg)\cdot\cos\left(\delta_3(190deg)\right)\right) + M_{\Phi4}(190deg)$$

$x_{19} := 16.697$

$$F_{45x}(190deg)\cdot\cos\left(\delta_3(190deg)\right) - F_{45y}(190deg)\cdot\sin\left(\delta_3(190deg)\right) \ldots = \left(1.338\times 10^4\right)$$
$$+ G_4\cdot\sin\left(\delta_3(190deg)\right) + \Phi_{4x}(190deg)\cdot\cos\left(\delta_3(190deg)\right) - \Phi_{4y}(190deg)\cdot\sin\left(\delta_3(190deg)\right)$$

$x_{19a} := 13380$

$$F_{45x}(200deg)\cdot\sin\left(\delta_3(200deg)\right) + F_{45y}(200deg)\cdot\cos\left(\delta_3(200deg)\right) \ldots = (19.051)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(200deg)\right) + \Phi_{4x}(200deg)\cdot\sin\left(\delta_3(200deg)\right) + \Phi_{4y}(200deg)\cdot\cos\left(\delta_3(200deg)\right)\right) + M_{\Phi4}(200deg)$$

$x_{20} := 19.051$

$$F_{45x}(200deg)\cdot\cos\left(\delta_3(200deg)\right) - F_{45y}(200deg)\cdot\sin\left(\delta_3(200deg)\right) \ldots = \left(3.338\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(200deg)\right) + \Phi_{4x}(200deg)\cdot\cos\left(\delta_3(200deg)\right) - \Phi_{4y}(200deg)\cdot\sin\left(\delta_3(200deg)\right)$$

$x_{20a} := 3388$

$$F_{45x}(210deg)\cdot\sin\left(\delta_3(210deg)\right) + F_{45y}(210deg)\cdot\cos\left(\delta_3(210deg)\right) \ldots = (15.857)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(210deg)\right) + \Phi_{4x}(210deg)\cdot\sin\left(\delta_3(210deg)\right) + \Phi_{4y}(210deg)\cdot\cos\left(\delta_3(210deg)\right)\right) + M_{\Phi4}(210deg)$$

$x_{21} := 15.857$

$$F_{45x}(210deg)\cdot\cos\left(\delta_3(210deg)\right) - F_{45y}(210deg)\cdot\sin\left(\delta_3(210deg)\right) \ldots = \left(3.446\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(210deg)\right) + \Phi_{4x}(210deg)\cdot\cos\left(\delta_3(210deg)\right) - \Phi_{4y}(210deg)\cdot\sin\left(\delta_3(210deg)\right)$$

$x_{21a} := 3446$

$$F_{45x}(220deg)\cdot\sin\left(\delta_3(220deg)\right) + F_{45y}(220deg)\cdot\cos\left(\delta_3(220deg)\right) \ldots = (6.736)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(220deg)\right) + \Phi_{4x}(220deg)\cdot\sin\left(\delta_3(220deg)\right) + \Phi_{4y}(220deg)\cdot\cos\left(\delta_3(220deg)\right)\right) + M_{\Phi4}(220deg)$$

$x_{22} := 6.736$

$$F_{45x}(220deg)\cdot\cos\left(\delta_3(220deg)\right) - F_{45y}(220deg)\cdot\sin\left(\delta_3(220deg)\right) \ldots = \left(3.054\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(220deg)\right) + \Phi_{4x}(220deg)\cdot\cos\left(\delta_3(220deg)\right) - \Phi_{4y}(220deg)\cdot\sin\left(\delta_3(220deg)\right)$$

$x_{22a} := 3054$

$$F_{45x}(230deg)\cdot\sin\left(\delta_3(230deg)\right) + F_{45y}(230deg)\cdot\cos\left(\delta_3(230deg)\right) \ldots = (-5.004)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(230deg)\right) + \Phi_{4x}(230deg)\cdot\sin\left(\delta_3(230deg)\right) + \Phi_{4y}(230deg)\cdot\cos\left(\delta_3(230deg)\right)\right) + M_{\Phi4}(230deg)$$

$x_{23} := -5.004$

$$F_{45x}(230deg)\cdot\cos\left(\delta_3(230deg)\right) - F_{45y}(230deg)\cdot\sin\left(\delta_3(230deg)\right) \ldots = \left(2.178\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(230deg)\right) + \Phi_{4x}(230deg)\cdot\cos\left(\delta_3(230deg)\right) - \Phi_{4y}(230deg)\cdot\sin\left(\delta_3(230deg)\right)$$

$x_{23a} := 2178$

$$F_{45x}(240deg)\cdot\sin\left(\delta_3(240deg)\right) + F_{45y}(240deg)\cdot\cos\left(\delta_3(240deg)\right) \ldots = (-14.452)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(240deg)\right) + \Phi_{4x}(240deg)\cdot\sin\left(\delta_3(240deg)\right) + \Phi_{4y}(240deg)\cdot\cos\left(\delta_3(240deg)\right)\right) + M_{\Phi4}(240deg)$$

$x_{24} := -14.452$

$$F_{45x}(240deg)\cdot\cos\left(\delta_3(240deg)\right) - F_{45y}(240deg)\cdot\sin\left(\delta_3(240deg)\right) \ldots = \left(1.099\times 10^3\right)$$
$$+ G_4\cdot\sin\left(\delta_3(240deg)\right) + \Phi_{4x}(240deg)\cdot\cos\left(\delta_3(240deg)\right) - \Phi_{4y}(240deg)\cdot\sin\left(\delta_3(240deg)\right)$$

$x_{24a} := 1099$

$$F_{45x}(250deg)\cdot\sin\left(\delta_3(250deg)\right) + F_{45y}(250deg)\cdot\cos\left(\delta_3(250deg)\right) \ldots = (-18.641)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(250deg)\right) + \Phi_{4x}(250deg)\cdot\sin\left(\delta_3(250deg)\right) + \Phi_{4y}(250deg)\cdot\cos\left(\delta_3(250deg)\right)\right) + M_{\Phi4}(250deg)$$

$x_{25} := -18.641$

$$F_{45x}(250deg)\cdot\cos\left(\delta_3(250deg)\right) - F_{45y}(250deg)\cdot\sin\left(\delta_3(250deg)\right) \ldots = (144.06)$$
$$+ G_4\cdot\sin\left(\delta_3(250deg)\right) + \Phi_{4x}(250deg)\cdot\cos\left(\delta_3(250deg)\right) - \Phi_{4y}(250deg)\cdot\sin\left(\delta_3(250deg)\right)$$

$x_{25a} := 144.06$

$$F_{45x}(260deg)\cdot\sin\left(\delta_3(260deg)\right) + F_{45y}(260deg)\cdot\cos\left(\delta_3(260deg)\right) \ldots = (-17.583)$$
$$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(260deg)\right) + \Phi_{4x}(260deg)\cdot\sin\left(\delta_3(260deg)\right) + \Phi_{4y}(260deg)\cdot\cos\left(\delta_3(260deg)\right)\right) + M_{\Phi4}(260deg)$$

$x_{26} := -17.583$

$F_{45x}(260deg)\cdot\cos\left(\delta_3(260deg)\right) - F_{45y}(260deg)\cdot\sin\left(\delta_3(260deg)\right) \ldots = (-505.278)$
$+ G_4\cdot\sin\left(\delta_3(260deg)\right) + \Phi_{4x}(260deg)\cdot\cos\left(\delta_3(260deg)\right) - \Phi_{4y}(260deg)\cdot\sin\left(\delta_3(260deg)\right)$

$x_{26a} := -505.278$

$F_{45x}(270deg)\cdot\sin\left(\delta_3(270deg)\right) + F_{45y}(270deg)\cdot\cos\left(\delta_3(270deg)\right) \ldots = (-13.179)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(270deg)\right) + \Phi_{4x}(270deg)\cdot\sin\left(\delta_3(270deg)\right) + \Phi_{4y}(270deg)\cdot\cos\left(\delta_3(270deg)\right)\right) + M_{\Phi 4}(270deg)$

$x_{27} := -13.179$

$F_{45x}(270deg)\cdot\cos\left(\delta_3(270deg)\right) - F_{45y}(270deg)\cdot\sin\left(\delta_3(270deg)\right) \ldots = (-834.255)$
$+ G_4\cdot\sin\left(\delta_3(270deg)\right) + \Phi_{4x}(270deg)\cdot\cos\left(\delta_3(270deg)\right) - \Phi_{4y}(270deg)\cdot\sin\left(\delta_3(270deg)\right)$

$x_{27a} := -834.255$

$F_{45x}(280deg)\cdot\sin\left(\delta_3(280deg)\right) + F_{45y}(280deg)\cdot\cos\left(\delta_3(280deg)\right) \ldots = (-7.664)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(280deg)\right) + \Phi_{4x}(280deg)\cdot\sin\left(\delta_3(280deg)\right) + \Phi_{4y}(280deg)\cdot\cos\left(\delta_3(280deg)\right)\right) + M_{\Phi 4}(280deg)$

$x_{28} := -7.664$

$F_{45x}(280deg)\cdot\cos\left(\delta_3(280deg)\right) - F_{45y}(280deg)\cdot\sin\left(\delta_3(280deg)\right) \ldots = (-925.789)$
$+ G_4\cdot\sin\left(\delta_3(280deg)\right) + \Phi_{4x}(280deg)\cdot\cos\left(\delta_3(280deg)\right) - \Phi_{4y}(280deg)\cdot\sin\left(\delta_3(280deg)\right)$

$x_{28a} := -925.789$

$F_{45x}(290deg)\cdot\sin\left(\delta_3(290deg)\right) + F_{45y}(290deg)\cdot\cos\left(\delta_3(290deg)\right) \ldots = (-2.572)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(290deg)\right) + \Phi_{4x}(290deg)\cdot\sin\left(\delta_3(290deg)\right) + \Phi_{4y}(290deg)\cdot\cos\left(\delta_3(290deg)\right)\right) + M_{\Phi 4}(290deg)$

$x_{29} := -2.572$

$F_{45x}(290deg)\cdot\cos\left(\delta_3(290deg)\right) - F_{45y}(290deg)\cdot\sin\left(\delta_3(290deg)\right) \ldots = (-882.952)$
$+ G_4\cdot\sin\left(\delta_3(290deg)\right) + \Phi_{4x}(290deg)\cdot\cos\left(\delta_3(290deg)\right) - \Phi_{4y}(290deg)\cdot\sin\left(\delta_3(290deg)\right)$

$x_{29a} := -882.952$

$F_{45x}(300deg)\cdot\sin\left(\delta_3(300deg)\right) + F_{45y}(300deg)\cdot\cos\left(\delta_3(300deg)\right) \ldots = (1.452)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(300deg)\right) + \Phi_{4x}(300deg)\cdot\sin\left(\delta_3(300deg)\right) + \Phi_{4y}(300deg)\cdot\cos\left(\delta_3(300deg)\right)\right) + M_{\Phi 4}(300deg)$

$x_{30} := 1.452$

$F_{45x}(300deg)\cdot\cos\left(\delta_3(300deg)\right) - F_{45y}(300deg)\cdot\sin\left(\delta_3(300deg)\right) \ldots = (-784.708)$
$+ G_4\cdot\sin\left(\delta_3(300deg)\right) + \Phi_{4x}(300deg)\cdot\cos\left(\delta_3(300deg)\right) - \Phi_{4y}(300deg)\cdot\sin\left(\delta_3(300deg)\right)$

$x_{30a} := -784.708$

$F_{45x}(310deg)\cdot\sin\left(\delta_3(310deg)\right) + F_{45y}(310deg)\cdot\cos\left(\delta_3(310deg)\right) \ldots = (4.351)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(310deg)\right) + \Phi_{4x}(310deg)\cdot\sin\left(\delta_3(310deg)\right) + \Phi_{4y}(310deg)\cdot\cos\left(\delta_3(310deg)\right)\right) + M_{\Phi 4}(310deg)$

$x_{31} := 4.351$

$F_{45x}(310deg)\cdot\cos\left(\delta_3(310deg)\right) - F_{45y}(310deg)\cdot\sin\left(\delta_3(310deg)\right) \ldots = (-677.358)$
$+ G_4\cdot\sin\left(\delta_3(310deg)\right) + \Phi_{4x}(310deg)\cdot\cos\left(\delta_3(310deg)\right) - \Phi_{4y}(310deg)\cdot\sin\left(\delta_3(310deg)\right)$

$x_{31a} := -677.358$

$F_{45x}(320deg)\cdot\sin\left(\delta_3(320deg)\right) + F_{45y}(320deg)\cdot\cos\left(\delta_3(320deg)\right) \ldots = (6.308)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(320deg)\right) + \Phi_{4x}(320deg)\cdot\sin\left(\delta_3(320deg)\right) + \Phi_{4y}(320deg)\cdot\cos\left(\delta_3(320deg)\right)\right) + M_{\Phi 4}(320deg)$

$x_{32} := 6.308$

$F_{45x}(320deg)\cdot\cos\left(\delta_3(320deg)\right) - F_{45y}(320deg)\cdot\sin\left(\delta_3(320deg)\right) \ldots = (-582.695)$
$+ G_4\cdot\sin\left(\delta_3(320deg)\right) + \Phi_{4x}(320deg)\cdot\cos\left(\delta_3(320deg)\right) - \Phi_{4y}(320deg)\cdot\sin\left(\delta_3(320deg)\right)$

$x_{32a} := -582.695$

$F_{45x}(330deg)\cdot\sin\left(\delta_3(330deg)\right) + F_{45y}(330deg)\cdot\cos\left(\delta_3(330deg)\right) \ldots = (7.548)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(330deg)\right) + \Phi_{4x}(330deg)\cdot\sin\left(\delta_3(330deg)\right) + \Phi_{4y}(330deg)\cdot\cos\left(\delta_3(330deg)\right)\right) + M_{\Phi4}(330deg)$

$x_{33} := 7.548$

$F_{45x}(330deg)\cdot\cos\left(\delta_3(330deg)\right) - F_{45y}(330deg)\cdot\sin\left(\delta_3(330deg)\right) \ldots = (-508.242)$
$+ G_4\cdot\sin\left(\delta_3(330deg)\right) + \Phi_{4x}(330deg)\cdot\cos\left(\delta_3(330deg)\right) - \Phi_{4y}(330deg)\cdot\sin\left(\delta_3(330deg)\right)$

$x_{33a} := -508.242$

$F_{45x}(340deg)\cdot\sin\left(\delta_3(340deg)\right) + F_{45y}(340deg)\cdot\cos\left(\delta_3(340deg)\right) \ldots = (8.245)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(340deg)\right) + \Phi_{4x}(340deg)\cdot\sin\left(\delta_3(340deg)\right) + \Phi_{4y}(340deg)\cdot\cos\left(\delta_3(340deg)\right)\right) + M_{\Phi4}(340deg)$

$x_{34} := 8.245$

$F_{45x}(340deg)\cdot\cos\left(\delta_3(340deg)\right) - F_{45y}(340deg)\cdot\sin\left(\delta_3(340deg)\right) \ldots = (-454.401)$
$+ G_4\cdot\sin\left(\delta_3(340deg)\right) + \Phi_{4x}(340deg)\cdot\cos\left(\delta_3(340deg)\right) - \Phi_{4y}(340deg)\cdot\sin\left(\delta_3(340deg)\right)$

$x_{34a} := -454.401$

$F_{45x}(350deg)\cdot\sin\left(\delta_3(350deg)\right) + F_{45y}(350deg)\cdot\cos\left(\delta_3(350deg)\right) \ldots = (8.506)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(350deg)\right) + \Phi_{4x}(350deg)\cdot\sin\left(\delta_3(350deg)\right) + \Phi_{4y}(350deg)\cdot\cos\left(\delta_3(350deg)\right)\right) + M_{\Phi4}(350deg)$

$x_{35} := 8.506$

$F_{45x}(350deg)\cdot\cos\left(\delta_3(350deg)\right) - F_{45y}(350deg)\cdot\sin\left(\delta_3(350deg)\right) \ldots = (-418.446)$
$+ G_4\cdot\sin\left(\delta_3(350deg)\right) + \Phi_{4x}(350deg)\cdot\cos\left(\delta_3(350deg)\right) - \Phi_{4y}(350deg)\cdot\sin\left(\delta_3(350deg)\right)$

$x_{35a} := -418.446$

$F_{45x}(360deg)\cdot\sin\left(\delta_3(360deg)\right) + F_{45y}(360deg)\cdot\cos\left(\delta_3(360deg)\right) \ldots = (8.377)$
$+ 0.5\cdot\left(-G_4\cdot\cos\left(\delta_3(360deg)\right) + \Phi_{4x}(360deg)\cdot\sin\left(\delta_3(360deg)\right) + \Phi_{4y}(360deg)\cdot\cos\left(\delta_3(360deg)\right)\right) + M_{\Phi4}(360deg)$

$x_{36} := 8.377$

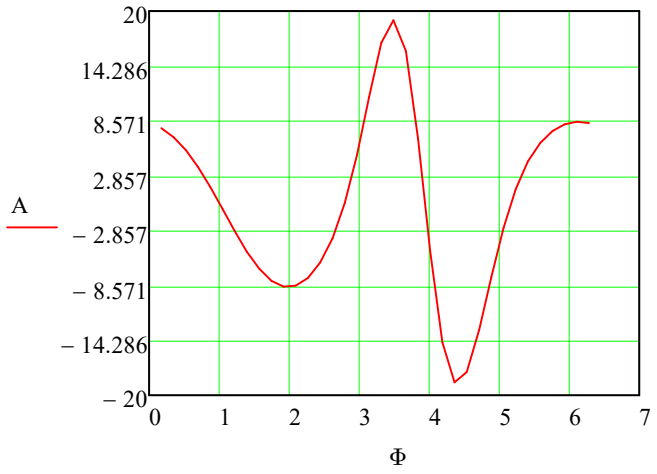
$F_{45x}(360deg)\cdot\cos\left(\delta_3(360deg)\right) - F_{45y}(360deg)\cdot\sin\left(\delta_3(360deg)\right) \ldots = \left(-3.763\times 10^{3}\right)$
$+ G_4\cdot\sin\left(\delta_3(360deg)\right) + \Phi_{4x}(360deg)\cdot\cos\left(\delta_3(360deg)\right) - \Phi_{4y}(360deg)\cdot\sin\left(\delta_3(360deg)\right)$

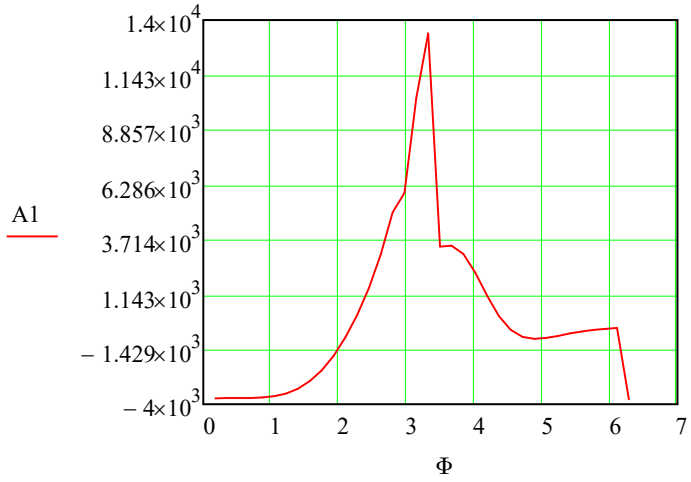
$x_{36a} := -3763$

$$A := \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \\ x_9 \\ x_{10} \\ x_{11} \\ x_{12} \\ x_{13} \\ x_{14} \\ x_{15} \\ x_{16} \\ x_{17} \\ x_{18} \\ x_{19} \\ x_{20} \\ x_{21} \\ x_{22} \\ x_{23} \\ x_{24} \\ x_{25} \\ x_{26} \\ x_{27} \\ x_{28} \\ x_{29} \\ x_{30} \\ x_{31} \\ x_{32} \\ x_{33} \\ x_{34} \\ x_{35} \\ x_{36} \end{pmatrix}$$

$$A1 := \begin{pmatrix} x_{1a} \\ x_{2a} \\ x_{3a} \\ x_{4a} \\ x_{5a} \\ x_{6a} \\ x_{7a} \\ x_{8a} \\ x_{9a} \\ x_{10a} \\ x_{11a} \\ x_{12a} \\ x_{13a} \\ x_{14a} \\ x_{15a} \\ x_{16a} \\ x_{17a} \\ x_{18a} \\ x_{19a} \\ x_{20a} \\ x_{21a} \\ x_{22a} \\ x_{23a} \\ x_{24a} \\ x_{25a} \\ x_{26a} \\ x_{27a} \\ x_{28a} \\ x_{29a} \\ x_{30a} \\ x_{31a} \\ x_{32a} \\ x_{33a} \\ x_{34a} \\ x_{35a} \\ x_{36a} \end{pmatrix}$$

$$\Phi := \begin{pmatrix} 10\text{deg} \\ 20\text{deg} \\ 30\text{deg} \\ 40\text{deg} \\ 50\text{deg} \\ 60\text{deg} \\ 70\text{deg} \\ 80\text{deg} \\ 90\text{deg} \\ 100\text{deg} \\ 110\text{deg} \\ 120\text{deg} \\ 130\text{deg} \\ 140\text{deg} \\ 150\text{deg} \\ 160\text{deg} \\ 170\text{deg} \\ 180\text{deg} \\ 190\text{deg} \\ 200\text{deg} \\ 210\text{deg} \\ 220\text{deg} \\ 230\text{deg} \\ 240\text{deg} \\ 250\text{deg} \\ 260\text{deg} \\ 270\text{deg} \\ 280\text{deg} \\ 290\text{deg} \\ 300\text{deg} \\ 310\text{deg} \\ 320\text{deg} \\ 330\text{deg} \\ 340\text{deg} \\ 350\text{deg} \\ 360\text{deg} \end{pmatrix}$$





$F_{45x}(251deg)\cdot\sin(\delta_3(251deg)) + F_{45y}(251deg)\cdot\cos(\delta_3(251deg)) \ldots = (-18.75)$
$+ 0.5(-G_4\cdot\cos(\delta_3(251deg)) + \Phi_{4x}(251deg)\cdot\sin(\delta_3(251deg)) + \Phi_{4v}(251deg)\cdot\cos(\delta_3(251deg))) + M_{\Phi4}(251deg)$

$F_{45x}(252deg)\cdot\sin(\delta_3(252deg)) + F_{45y}(252deg)\cdot\cos(\delta_3(252deg)) \ldots = (-18.805)$
$+ 0.5(-G_4\cdot\cos(\delta_3(252deg)) + \Phi_{4x}(252deg)\cdot\sin(\delta_3(252deg)) + \Phi_{4v}(252deg)\cdot\cos(\delta_3(252deg))) + M_{\Phi4}(252deg)$

$F_{45x}(253deg)\cdot\sin(\delta_3(253deg)) + F_{45y}(253deg)\cdot\cos(\delta_3(253deg)) \ldots = (-18.81)$
$+ 0.5(-G_4\cdot\cos(\delta_3(253deg)) + \Phi_{4x}(253deg)\cdot\sin(\delta_3(253deg)) + \Phi_{4v}(253deg)\cdot\cos(\delta_3(253deg))) + M_{\Phi4}(253deg)$

$F_{45x}(251deg)\cdot\sin(\delta_3(254deg)) + F_{45y}(254deg)\cdot\cos(\delta_3(254deg)) \ldots = (-4.63)$
$+ 0.5(-G_4\cdot\cos(\delta_3(254deg)) + \Phi_{4x}(254deg)\cdot\sin(\delta_3(254deg)) + \Phi_{4v}(254deg)\cdot\cos(\delta_3(254deg))) + M_{\Phi4}(254deg)$

$F_{45x}(201deg)\cdot\sin(\delta_3(201deg)) + F_{45y}(201deg)\cdot\cos(\delta_3(201deg)) \ldots = (19.012)$
$+ 0.5\cdot(-G_4\cdot\cos(\delta_3(201deg)) + \Phi_{4x}(201deg)\cdot\sin(\delta_3(201deg)) + \Phi_{4v}(201deg)\cdot\cos(\delta_3(201deg))) + M_{\Phi4}(201deg)$

$F_{45x}(202deg)\cdot\sin(\delta_3(202deg)) + F_{45y}(202deg)\cdot\cos(\delta_3(202deg)) \ldots = (18.914)$
$+ 0.5\cdot(-G_4\cdot\cos(\delta_3(202deg)) + \Phi_{4x}(202deg)\cdot\sin(\delta_3(202deg)) + \Phi_{4y}(202deg)\cdot\cos(\delta_3(202deg))) + M_{\Phi4}(202deg)$

$F_{45x}(191deg)\cdot\cos(\delta_3(191deg)) - F_{45y}(191deg)\cdot\sin(\delta_3(191deg)) \ldots = (1.366\times10^4)$
$+ G_4\cdot\sin(\delta_3(191deg)) + \Phi_{4x}(191deg)\cdot\cos(\delta_3(191deg)) - \Phi_{4v}(191deg)\cdot\sin(\delta_3(191deg))$

$F_{45x}(192deg)\cdot\cos(\delta_3(192deg)) - F_{45y}(192deg)\cdot\sin(\delta_3(192deg)) \ldots = (1.392\times10^4)$
$+ G_4\cdot\sin(\delta_3(192deg)) + \Phi_{4x}(192deg)\cdot\cos(\delta_3(192deg)) - \Phi_{4v}(192deg)\cdot\sin(\delta_3(192deg))$

$F_{45x}(193deg)\cdot\cos(\delta_3(193deg)) - F_{45y}(193deg)\cdot\sin(\delta_3(193deg)) \ldots = (1.417\times10^4)$
$+ G_4\cdot\sin(\delta_3(193deg)) + \Phi_{4x}(193deg)\cdot\cos(\delta_3(193deg)) - \Phi_{4y}(193deg)\cdot\sin(\delta_3(193deg))$

$N_4 := 14170$

$F_{45x}(194deg)\cdot\cos(\delta_3(194deg)) - F_{45y}(194deg)\cdot\sin(\delta_3(194deg)) \ldots = (3.115\times10^3)$
$+ G_4\cdot\sin(\delta_3(194deg)) + \Phi_{4x}(194deg)\cdot\cos(\delta_3(194deg)) - \Phi_{4y}(194deg)\cdot\sin(\delta_3(194deg))$

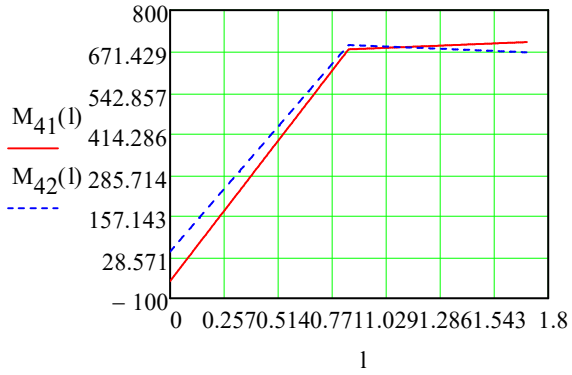
$l := 0, 0.01 .. 1.7$

$F_{45x}(253deg) = (-96.593)$ $\quad$ $F_{45y}(253deg) = (1.016\times10^3)$

$$M_{41}(l) := \begin{cases} -96.593\cdot l\cdot\sin(\delta_3(253deg)) + 1016\cdot l\cdot\cos(\delta_3(253deg)) \ldots \\ \quad + 0.5(l-0.85)\cdot\left(-G_4\cdot\cos(\delta_3(253deg)) + \Phi_{4x}(253deg)\cdot\sin(\delta_3(253deg)) \ldots \right. \\ \quad\quad \left. + \Phi_{4y}(253deg)\cdot\cos(\delta_3(253deg))\right) + M_{\Phi4}(253deg) & \text{if } l > 0.85 \\ -96.593l\cdot\sin(\delta_3(253deg)) + 1016\cdot l\cdot\cos(\delta_3(253deg)) + M_{\Phi4}(253deg) & \text{otherwise} \end{cases}$$

$F_{45x}(201deg) = (415.312)$ $\quad$ $F_{45y}(201deg) = (651.877)$

$$M_{42}(l) := \begin{cases} 415.312\cdot l\cdot\sin\left(\delta_3(201\,deg)\right) + 651.877\cdot l\cdot\cos\left(\delta_3(201\,deg)\right) \ldots \\ \quad + 0.5(l-0.85)\left(-G_4\cdot\cos\left(\delta_3(201\,deg)\right) + \Phi_{4x}(201\,deg)\cdot\sin\left(\delta_3(201\,deg)\right) \ldots \right) + M_{\Phi4}(201\,deg) \\ \quad\quad + \Phi_{4y}(201\,deg)\cdot\cos\left(\delta_3(201\,deg)\right) \\ 415.312l\cdot\sin\left(\delta_3(201\,deg)\right) + 651.877\cdot l\cdot\cos\left(\delta_3(201\,deg)\right) + M_{\Phi4}(201\,deg) \end{cases} \quad \begin{matrix} \text{if } l > 0.85 \\ \\ \\ \text{otherwise} \end{matrix}$$



$$M_{4max} := \left|M_{41}(1.7)\right| = 701.031$$

Условие на сжатие:G.t.>N/A

$$D_4 := \sqrt{\frac{4N_4}{\pi\cdot G_t}} = 8.174\times 10^{-3} \quad м$$

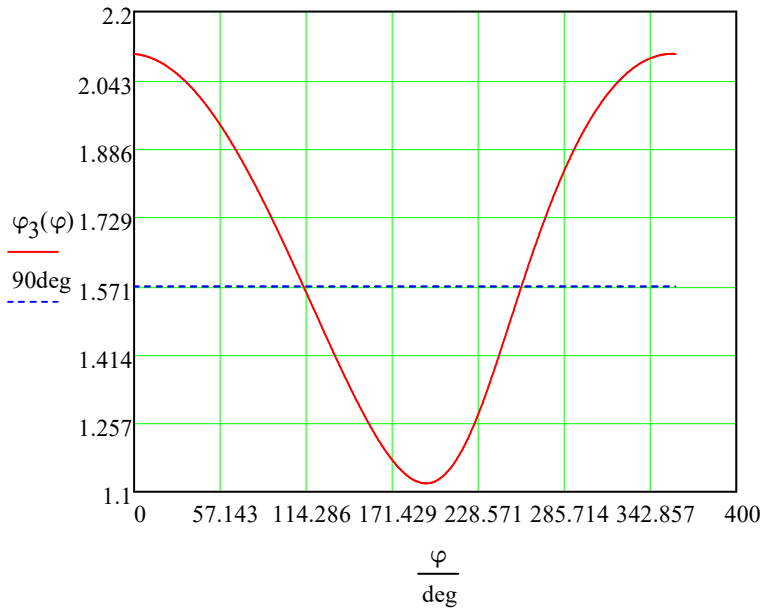
Условие на изгиб: G.t>M.4max/W.p

$$D_4 := \sqrt[3]{\frac{16M_{4max}}{\pi\cdot G_t}} = 0.024 \quad \text{по Ra40} \quad D_4 := 0.024 \quad м$$

$$J_{S4} := \frac{m_4\cdot\left(l_{DH}^{\,2} + 3\,\frac{D_4^{\,2}}{4}\right)}{12} = 52.991 \quad кг\cdot м^2$$

$$m_4 := \rho\cdot\pi\,\frac{D_4^{\,2}\cdot l_{DH}}{4} = 6.037 \quad кг$$

Для звена 3:



$$F_{34x}(10\,deg)\cdot\sin\left(\varphi_3(10\,deg)\right) + F_{34y}(10\,deg)\cdot\cos\left(\varphi_3(10\,deg)\right) \ldots = \left(-3.884\times 10^3\right)$$
$$+ 0.5\left(G_3\cdot\cos\left(\varphi_3(10\,deg)\right) + \Phi_{3x}(10\,deg)\cdot\sin\left(\varphi_3(10\,deg)\right) + \Phi_{3y}(10\,deg)\cdot\cos\left(\varphi_3(10\,deg)\right)\right) + M_{\Phi3}(10\,deg)$$

$x_{1} := -3884$

$$-F_{34x}(10deg)\cdot\cos\left(\varphi_3(10deg)\right) + F_{34y}(10deg)\cdot\sin\left(\varphi_3(10deg)\right) - G_3\cdot\sin\left(\varphi_3(10deg)\right) \ldots = \left(-3.524\times 10^{3}\right)$$
$$+\left(-\Phi_{3x}(10deg)\cdot\cos\left(\varphi_3(10deg)\right) + \Phi_{3y}(10deg)\cdot\sin\left(\varphi_3(10deg)\right)\right)$$

$x_{1a} := -3524$

$$F_{34x}(20deg)\cdot\sin\left(\varphi_3(20deg)\right) + F_{34y}(20deg)\cdot\cos\left(\varphi_3(20deg)\right) \ldots = \left(-3.912\times 10^{3}\right)$$
$$+0.5\left(G_3\cdot\cos\left(\varphi_3(20deg)\right) + \Phi_{3x}(20deg)\cdot\sin\left(\varphi_3(20deg)\right) + \Phi_{3y}(20deg)\cdot\cos\left(\varphi_3(20deg)\right)\right) + M_{\Phi 3}(20deg)$$

$x_{2} := -3912$

$$-F_{34x}(20deg)\cdot\cos\left(\varphi_3(20deg)\right) + F_{34y}(20deg)\cdot\sin\left(\varphi_3(20deg)\right) \ldots = \left(-3.408\times 10^{3}\right)$$
$$+\left(-G_3\cdot\sin\left(\varphi_3(20deg)\right)\right) - \Phi_{3x}(20deg)\cdot\cos\left(\varphi_3(20deg)\right) + \Phi_{3y}(20deg)\cdot\sin\left(\varphi_3(20deg)\right)$$

$x_{2a} := -3408$

$$F_{34x}(30deg)\cdot\sin\left(\varphi_3(30deg)\right) + F_{34y}(30deg)\cdot\cos\left(\varphi_3(30deg)\right) \ldots = \left(-3.973\times 10^{3}\right)$$
$$+0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(30deg)\right) + \Phi_{3x}(30deg)\cdot\sin\left(\varphi_3(30deg)\right) + \Phi_{3y}(30deg)\cdot\cos\left(\varphi_3(30deg)\right)\right) + M_{\Phi 3}(30deg)$$

$x_{3} := -3973$

$$-F_{34x}(30deg)\cdot\cos\left(\varphi_3(30deg)\right) + F_{34y}(30deg)\cdot\sin\left(\varphi_3(30deg)\right) \ldots = \left(-3.237\times 10^{3}\right)$$
$$+\left(-G_3\cdot\sin\left(\varphi_3(30deg)\right)\right) - \Phi_{3x}(30deg)\cdot\cos\left(\varphi_3(30deg)\right) + \Phi_{3y}(30deg)\cdot\sin\left(\varphi_3(30deg)\right)$$

$x_{3a} := -3237$

$$F_{34x}(40deg)\cdot\sin\left(\varphi_3(40deg)\right) + F_{34y}(40deg)\cdot\cos\left(\varphi_3(40deg)\right) \ldots = \left(-4.039\times 10^{3}\right)$$
$$+0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(40deg)\right) + \Phi_{3x}(40deg)\cdot\sin\left(\varphi_3(40deg)\right) + \Phi_{3y}(40deg)\cdot\cos\left(\varphi_3(40deg)\right)\right) + M_{\Phi 3}(40deg)$$

$x_{4} := -4039$

$$-F_{34x}(40deg)\cdot\cos\left(\varphi_3(40deg)\right) + F_{34y}(40deg)\cdot\sin\left(\varphi_3(40deg)\right) \ldots = \left(-3.007\times 10^{3}\right)$$
$$+\left(-G_3\cdot\sin\left(\varphi_3(40deg)\right)\right) - \Phi_{3x}(40deg)\cdot\cos\left(\varphi_3(40deg)\right) + \Phi_{3y}(40deg)\cdot\sin\left(\varphi_3(40deg)\right)$$

$x_{4a} := -3007$

$$F_{34x}(50deg)\cdot\sin\left(\varphi_3(50deg)\right) + F_{34y}(50deg)\cdot\cos\left(\varphi_3(50deg)\right) \ldots = \left(-4.076\times 10^{3}\right)$$
$$+0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(50deg)\right) + \Phi_{3x}(50deg)\cdot\sin\left(\varphi_3(50deg)\right) + \Phi_{3y}(50deg)\cdot\cos\left(\varphi_3(50deg)\right)\right) + M_{\Phi 3}(50deg)$$

$x_{5} := -4076$

$$-F_{34x}(50deg)\cdot\cos\left(\varphi_3(50deg)\right) + F_{34y}(50deg)\cdot\sin\left(\varphi_3(50deg)\right) \ldots = \left(-2.72\times 10^{3}\right)$$
$$+\left(-G_3\cdot\sin\left(\varphi_3(50deg)\right)\right) - \Phi_{3x}(50deg)\cdot\cos\left(\varphi_3(50deg)\right) + \Phi_{3y}(50deg)\cdot\sin\left(\varphi_3(50deg)\right)$$

$x_{5a} := -2720$

$$F_{34x}(60deg)\cdot\sin\left(\varphi_3(60deg)\right) + F_{34y}(60deg)\cdot\cos\left(\varphi_3(60deg)\right) \ldots = \left(-4.05\times 10^{3}\right)$$
$$+0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(60deg)\right) + \Phi_{3x}(60deg)\cdot\sin\left(\varphi_3(60deg)\right) + \Phi_{3y}(60deg)\cdot\cos\left(\varphi_3(60deg)\right)\right) + M_{\Phi 3}(60deg)$$

$x_{6} := -4050$

$$-F_{34x}(60deg)\cdot\cos\left(\varphi_3(60deg)\right) + F_{34y}(60deg)\cdot\sin\left(\varphi_3(60deg)\right) \ldots = \left(-2.39\times 10^{3}\right)$$
$$+\left(-G_3\cdot\sin\left(\varphi_3(60deg)\right)\right) - \Phi_{3x}(60deg)\cdot\cos\left(\varphi_3(60deg)\right) + \Phi_{3y}(60deg)\cdot\sin\left(\varphi_3(60deg)\right)$$

$x_{6a} := -2390$

$$F_{34x}(70deg)\cdot\sin\left(\varphi_3(70deg)\right) + F_{34y}(70deg)\cdot\cos\left(\varphi_3(70deg)\right) \ldots = \left(-3.925\times 10^{3}\right)$$
$$+0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(70deg)\right) + \Phi_{3x}(70deg)\cdot\sin\left(\varphi_3(70deg)\right) + \Phi_{3y}(70deg)\cdot\cos\left(\varphi_3(70deg)\right)\right) + M_{\Phi 3}(70deg)$$

$x_{7} := -3925$

$$-F_{34x}(70deg)\cdot\cos\left(\varphi_3(70deg)\right) + F_{34y}(70deg)\cdot\sin\left(\varphi_3(70deg)\right) \ldots = \left(-2.044\times 10^{3}\right)$$
$$+\left(-G_3\cdot\sin\left(\varphi_3(70deg)\right)\right) - \Phi_{3x}(70deg)\cdot\cos\left(\varphi_3(70deg)\right) + \Phi_{3y}(70deg)\cdot\sin\left(\varphi_3(70deg)\right)$$

$x_{7a} := -2044$

$F_{34x}(80deg)\cdot\sin(\varphi_3(80deg)) + F_{34y}(80deg)\cdot\cos(\varphi_3(80deg)) \ldots = (-3.667\times 10^3)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(80deg)) + \Phi_{3x}(80deg)\cdot\sin(\varphi_3(80deg)) + \Phi_{3y}(80deg)\cdot\cos(\varphi_3(80deg))) + M_{\Phi 3}(80deg)$

$x_8 := -3667$

$-F_{34x}(80deg)\cdot\cos(\varphi_3(80deg)) + F_{34y}(80deg)\cdot\sin(\varphi_3(80deg)) \ldots = (-1.721\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(80deg))) - \Phi_{3x}(80deg)\cdot\cos(\varphi_3(80deg)) + \Phi_{3y}(80deg)\cdot\sin(\varphi_3(80deg))$

$x_{8a} := -1721$

$F_{34x}(90deg)\cdot\sin(\varphi_3(90deg)) + F_{34y}(90deg)\cdot\cos(\varphi_3(90deg)) \ldots = (-3.256\times 10^3)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(90deg)) + \Phi_{3x}(90deg)\cdot\sin(\varphi_3(90deg)) + \Phi_{3y}(90deg)\cdot\cos(\varphi_3(90deg))) + M_{\Phi 3}(90deg)$

$x_9 := -3556$

$-F_{34x}(90deg)\cdot\cos(\varphi_3(90deg)) + F_{34y}(90deg)\cdot\sin(\varphi_3(90deg)) \ldots = (-1.473\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(90deg))) - \Phi_{3x}(90deg)\cdot\cos(\varphi_3(90deg)) + \Phi_{3y}(90deg)\cdot\sin(\varphi_3(90deg))$

$x_{9a} := -1473$

$F_{34x}(100deg)\cdot\sin(\varphi_3(100deg)) + F_{34y}(100deg)\cdot\cos(\varphi_3(100deg)) \ldots = (-2.685\times 10^3)$
$+ 0.5\cdot\begin{pmatrix} G_3\cdot\cos(\varphi_3(100deg)) + \Phi_{3x}(100deg)\cdot\sin(\varphi_3(100deg)) \ldots \\ + \Phi_{3y}(100deg)\cdot\cos(\varphi_3(100deg)) \end{pmatrix} + M_{\Phi 3}(100deg)$

$x_{10} := -2685$

$-F_{34x}(100deg)\cdot\cos(\varphi_3(100deg)) + F_{34y}(100deg)\cdot\sin(\varphi_3(100deg)) \ldots = (-1.354\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(100deg))) - \Phi_{3x}(100deg)\cdot\cos(\varphi_3(100deg)) + \Phi_{3y}(100deg)\cdot\sin(\varphi_3(100deg))$

$x_{10a} := -1354$

$F_{34x}(110deg)\cdot\sin(\varphi_3(110deg)) + F_{34y}(110deg)\cdot\cos(\varphi_3(110deg)) \ldots = (-1.967\times 10^3)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(110deg)) + \Phi_{3x}(110deg)\cdot\sin(\varphi_3(110deg)) + \Phi_{3y}(110deg)\cdot\cos(\varphi_3(110deg))) \ldots$
$+ M_{\Phi 3}(110deg)$

$x_{11} := -1967$

$-F_{34x}(110deg)\cdot\cos(\varphi_3(110deg)) + F_{34y}(110deg)\cdot\sin(\varphi_3(110deg)) \ldots = (-1.414\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(110deg))) - \Phi_{3x}(110deg)\cdot\cos(\varphi_3(110deg)) + \Phi_{3y}(110deg)\cdot\sin(\varphi_3(110deg))$

$x_{11a} := -1414$

$F_{34x}(120deg)\cdot\sin(\varphi_3(120deg)) - F_{34y}(120deg)\cdot\cos(\varphi_3(120deg)) \ldots = (-1.925\times 10^3)$
$+ 0.5\cdot(-G_3\cdot\sin(\varphi_3(120deg)) + \Phi_{3x}(120deg)\cdot\sin(\varphi_3(120deg)) - \Phi_{3y}(120deg)\cdot\cos(\varphi_3(120deg))) \ldots$
$+ M_{\Phi 3}(120deg)$

$x_{12} := -1925$

$F_{34x}(120deg)\cdot\cos(\varphi_3(120deg)) - F_{34y}(120deg)\cdot\sin(\varphi_3(120deg)) \ldots = (207.707)$
$+ G_3\cdot\cos(\varphi_3(120deg)) - \Phi_{3x}(120deg)\cdot\cos(\varphi_3(120deg)) - \Phi_{3y}(120deg)\cdot\sin(\varphi_3(120deg))$

$x_{12a} := 207.707$

$F_{34x}(130deg)\cdot\sin(\varphi_3(130deg)) - F_{34y}(130deg)\cdot\cos(\varphi_3(130deg)) \ldots = (-866.952)$
$+ 0.5\cdot[(-G_3\cdot\sin(\varphi_3(130deg)) + \Phi_{3x}(130deg)\cdot\sin(\varphi_3(130deg))) - \Phi_{3y}(130deg)\cdot\cos(\varphi_3(130deg))] \ldots$
$+ M_{\Phi 3}(130deg)$

$x_{13} := -866.952$

$$F_{34x}(130deg)\cdot\cos\left(\varphi_3(130deg)\right) - F_{34y}(130deg)\cdot\sin\left(\varphi_3(130deg)\right) \ldots = (837.035)$$
$$+ G_3\cdot\cos\left(\varphi_3(130deg)\right) - \Phi_{3x}(130deg)\cdot\cos\left(\varphi_3(130deg)\right) - \Phi_{3y}(130deg)\cdot\sin\left(\varphi_3(130deg)\right)$$

$x_{13a} := 837.035$

$$F_{34x}(140deg)\cdot\sin\left(\varphi_3(140deg)\right) - F_{34y}(140deg)\cdot\cos\left(\varphi_3(140deg)\right) \ldots = (480.76)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(140deg)\right) + \Phi_{3x}(140deg)\cdot\sin\left(\varphi_3(140deg)\right)\right) - \Phi_{3y}(140deg)\cdot\cos\left(\varphi_3(140deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(140deg)$$

$x_{14} := 480.76$

$$-F_{34x}(140deg)\cdot\cos\left(\varphi_3(140deg)\right) - F_{34y}(140deg)\cdot\sin\left(\varphi_3(140deg)\right) \ldots = \left(1.343\times 10^3\right)$$
$$+ G_3\cdot\cos\left(\varphi_3(140deg)\right) - \Phi_{3x}(140deg)\cdot\cos\left(\varphi_3(140deg)\right) - \Phi_{3y}(140deg)\cdot\sin\left(\varphi_3(140deg)\right)$$

$x_{14a} := 1343$

$$F_{34x}(150deg)\cdot\sin\left(\varphi_3(150deg)\right) - F_{34y}(150deg)\cdot\cos\left(\varphi_3(150deg)\right) \ldots = \left(2.175\times 10^3\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(150deg)\right) + \Phi_{3x}(150deg)\cdot\sin\left(\varphi_3(150deg)\right)\right) - \Phi_{3y}(150deg)\cdot\cos\left(\varphi_3(150deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(150deg)$$

$x_{15} := 2175$

$$-F_{34x}(150deg)\cdot\cos\left(\varphi_3(150deg)\right) - F_{34y}(150deg)\cdot\sin\left(\varphi_3(150deg)\right) \ldots = \left(1.62\times 10^3\right)$$
$$+ G_3\cdot\cos\left(\varphi_3(150deg)\right) - \Phi_{3x}(150deg)\cdot\cos\left(\varphi_3(150deg)\right) - \Phi_{3y}(150deg)\cdot\sin\left(\varphi_3(150deg)\right)$$

$x_{15a} := 1620$

$$F_{34x}(160deg)\cdot\sin\left(\varphi_3(160deg)\right) - F_{34y}(160deg)\cdot\cos\left(\varphi_3(160deg)\right) \ldots = \left(4.29\times 10^3\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(160deg)\right) + \Phi_{3x}(160deg)\cdot\sin\left(\varphi_3(160deg)\right)\right) - \Phi_{3y}(160deg)\cdot\cos\left(\varphi_3(160deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(160deg)$$

$x_{16} := 4290$

$$-F_{34x}(160deg)\cdot\cos\left(\varphi_3(160deg)\right) - F_{34y}(160deg)\cdot\sin\left(\varphi_3(160deg)\right) \ldots = \left(1.673\times 10^3\right)$$
$$+ G_3\cdot\cos\left(\varphi_3(160deg)\right) - \Phi_{3x}(160deg)\cdot\cos\left(\varphi_3(160deg)\right) - \Phi_{3y}(160deg)\cdot\sin\left(\varphi_3(160deg)\right)$$

$x_{16a} := 1673$

$$F_{34x}(170deg)\cdot\sin\left(\delta_3(170deg)\right) - F_{34y}(170deg)\cdot\cos\left(\varphi_3(170deg)\right) \ldots = \left(3.408\times 10^3\right)$$
$$+ 0.5\cdot\left(-G_3\cdot\sin\left(\varphi_3(170deg)\right) + \Phi_{3x}(170deg)\cdot\sin\left(\varphi_3(170deg)\right) + \Phi_{3y}(170deg)\cdot\cos\left(\varphi_3(170deg)\right)\right) \ldots$$
$$+ M_{\Phi 3}(170deg)$$

$x_{17} := 3408$

$$-F_{34x}(170deg)\cdot\cos\left(\varphi_3(170deg)\right) - F_{34y}(10deg)\cdot\sin\left(\varphi_3(170deg)\right) \ldots = \left(-2.02\times 10^3\right)$$
$$+ G_3\cdot\cos\left(\varphi_3(170deg)\right) - \Phi_{3x}(170deg)\cdot\cos\left(\varphi_3(170deg)\right) - \Phi_{3y}(170deg)\cdot\sin\left(\varphi_3(170deg)\right)$$

$x_{17a} := -2020$

$$F_{34x}(180deg)\cdot\sin\left(\varphi_3(180deg)\right) - F_{34y}(180deg)\cdot\cos\left(\varphi_3(180deg)\right) \ldots = \left(9.94\times 10^3\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(180deg)\right) + \Phi_{3x}(180deg)\cdot\sin\left(\varphi_3(180deg)\right)\right) - \Phi_{3y}(180deg)\cdot\cos\left(\varphi_3(180deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(180deg)$$

$x_{18} := 9940$

$$-F_{34x}(180deg)\cdot\cos\left(\varphi_3(180deg)\right) - F_{34y}(180deg)\cdot\sin\left(\varphi_3(180deg)\right) \ldots = \left(1.059\times 10^3\right)$$
$$+ G_3\cdot\cos\left(\varphi_3(180deg)\right) - \Phi_{3x}(180deg)\cdot\cos\left(\varphi_3(180deg)\right) - \Phi_{3y}(180deg)\cdot\sin\left(\varphi_3(180deg)\right)$$

$x_{18a} := 1059$

$F_{34x}(190deg)\cdot\sin(\varphi_3(190deg)) - F_{34y}(190deg)\cdot\cos(\varphi_3(190deg)) \ldots = (1.305\times 10^4)$
$+ 0.5\cdot\left[\left(-G_3\cdot\sin(\varphi_3(190deg)) + \Phi_{3x}(190deg)\cdot\sin(\varphi_3(190deg))\right) - \Phi_{3y}(190deg)\cdot\cos(\varphi_3(190deg))\right] \ldots$
$+ M_{\Phi 3}(190deg)$

$x_{19} := 13050$

$-F_{34x}(190deg)\cdot\cos(\varphi_3(190deg)) - F_{34y}(190deg)\cdot\sin(\varphi_3(190deg)) \ldots = (609.952)$
$+ G_3\cdot\cos(\varphi_3(190deg)) - \Phi_{3x}(190deg)\cdot\cos(\varphi_3(190deg)) - \Phi_{3y}(190deg)\cdot\sin(\varphi_3(190deg))$

$x_{19a} := 609.952$

$F_{34x}(200deg)\cdot\sin(\varphi_3(200deg)) - F_{34y}(200deg)\cdot\cos(\varphi_3(200deg)) \ldots = (3.077\times 10^3)$
$+ 0.5\cdot\left[\left(-G_3\cdot\sin(\varphi_3(200deg)) + \Phi_{3x}(200deg)\cdot\sin(\varphi_3(200deg))\right) - \Phi_{3y}(200deg)\cdot\cos(\varphi_3(200deg))\right] \ldots$
$+ M_{\Phi 3}(200deg)$

$x_{20} := 3077$

$-F_{34x}(200deg)\cdot\cos(\varphi_3(200deg)) - F_{34y}(200deg)\cdot\sin(\varphi_3(200deg)) \ldots = (1.273\times 10^3)$
$+ G_3\cdot\cos(\varphi_3(200deg)) - \Phi_{3x}(200deg)\cdot\cos(\varphi_3(200deg)) - \Phi_{3y}(200deg)\cdot\sin(\varphi_3(200deg))$

$x_{20a} := 1273$

$F_{34x}(210deg)\cdot\sin(\varphi_3(210deg)) - F_{34y}(210deg)\cdot\cos(\varphi_3(210deg)) \ldots = (3.149\times 10^3)$
$+ 0.5\cdot\left[\left(-G_3\cdot\sin(\varphi_3(210deg)) + \Phi_{3x}(210deg)\cdot\sin(\varphi_3(210deg))\right) - \Phi_{3y}(210deg)\cdot\cos(\varphi_3(210deg))\right] \ldots$
$+ M_{\Phi 3}(210deg)$

$x_{21} := 3149$

$-F_{34x}(210deg)\cdot\cos(\varphi_3(210deg)) - F_{34y}(210deg)\cdot\sin(\varphi_3(210deg)) \ldots = (1.234\times 10^3)$
$+ G_3\cdot\cos(\varphi_3(210deg)) - \Phi_{3x}(210deg)\cdot\cos(\varphi_3(210deg)) - \Phi_{3y}(210deg)\cdot\sin(\varphi_3(210deg))$

$x_{21a} := 1234$

$F_{34x}(220deg)\cdot\sin(\varphi_3(220deg)) - F_{34y}(220deg)\cdot\cos(\varphi_3(220deg)) \ldots = (2.621\times 10^3)$
$+ 0.5\cdot\left[\left(-G_3\cdot\sin(\varphi_3(220deg)) + \Phi_{3x}(220deg)\cdot\sin(\varphi_3(220deg))\right) - \Phi_{3y}(220deg)\cdot\cos(\varphi_3(220deg))\right] \ldots$
$+ M_{\Phi 3}(220deg)$

$x_{22} := 2621$

$-F_{34x}(220deg)\cdot\cos(\varphi_3(220deg)) - F_{34y}(220deg)\cdot\sin(\varphi_3(220deg)) \ldots = (1.206\times 10^3)$
$+ G_3\cdot\cos(\varphi_3(220deg)) - \Phi_{3x}(220deg)\cdot\cos(\varphi_3(220deg)) - \Phi_{3y}(220deg)\cdot\sin(\varphi_3(220deg))$

$x_{22a} := 1206$

$F_{34x}(230deg)\cdot\sin(\varphi_3(230deg)) - F_{34y}(230deg)\cdot\cos(\varphi_3(230deg)) \ldots = (1.528\times 10^3)$
$+ 0.5\cdot\left[\left(-G_3\cdot\sin(\varphi_3(230deg)) + \Phi_{3x}(230deg)\cdot\sin(\varphi_3(230deg))\right) - \Phi_{3y}(230deg)\cdot\cos(\varphi_3(230deg))\right] \ldots$
$+ M_{\Phi 3}(230deg)$

$x_{23} := 1528$

$-F_{34x}(230deg)\cdot\cos(\varphi_3(230deg)) - F_{34y}(230deg)\cdot\sin(\varphi_3(230deg)) \ldots = (1.115\times 10^3)$
$+ G_3\cdot\cos(\varphi_3(230deg)) - \Phi_{3x}(230deg)\cdot\cos(\varphi_3(230deg)) - \Phi_{3y}(230deg)\cdot\sin(\varphi_3(230deg))$

$x_{23a} := 1115$

$F_{34x}(240deg)\cdot\sin(\varphi_3(240deg)) - F_{34y}(240deg)\cdot\cos(\varphi_3(240deg)) \ldots = (210.008)$
$+ 0.5\cdot\left(-G_3\cdot\sin(\varphi_3(240deg)) + \Phi_{3x}(240deg)\cdot\sin(\varphi_3(240deg)) - \Phi_{3y}(240deg)\cdot\cos(\varphi_3(240deg))\right) \ldots$
$+ M_{\Phi 3}(240deg)$

$x_{24} := 210.008$

$-F_{34x}(240deg)\cdot\cos(\varphi_3(240deg)) - F_{34y}(240deg)\cdot\sin(\varphi_3(240deg)) \ldots = (879.711)$
$+ G_3\cdot\cos(\varphi_3(240deg)) - \Phi_{3x}(240deg)\cdot\cos(\varphi_3(240deg)) - \Phi_{3y}(240deg)\cdot\sin(\varphi_3(240deg))$

$x_{24a} := 879.711$

$$F_{34x}(250deg)\cdot\sin\left(\varphi_3(250deg)\right) - F_{34y}(250deg)\cdot\cos\left(\varphi_3(250deg)\right) \ldots = (-948.424)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(250deg)\right) + \Phi_{3x}(250deg)\cdot\sin\left(\varphi_3(250deg)\right)\right) - \Phi_{3y}(250deg)\cdot\cos\left(\varphi_3(250deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(250deg)$$

$x_{25}:= -948.424$

$$-F_{34x}(250deg)\cdot\cos\left(\varphi_3(250deg)\right) - F_{34y}(250deg)\cdot\sin\left(\varphi_3(250deg)\right) \ldots = (523.555)$$
$$+ G_3\cdot\cos\left(\varphi_3(250deg)\right) - \Phi_{3x}(250deg)\cdot\cos\left(\varphi_3(250deg)\right) - \Phi_{3y}(250deg)\cdot\sin\left(\varphi_3(250deg)\right)$$

$x_{25a}:= 523.555$

$$F_{34x}(260deg)\cdot\sin\left(\varphi_3(260deg)\right) + F_{34y}(260deg)\cdot\cos\left(\varphi_3(260deg)\right) \ldots = (-959.897)$$
$$+ 0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(260deg)\right) + \Phi_{3x}(260deg)\cdot\sin\left(\varphi_3(260deg)\right) + \Phi_{3y}(260deg)\cdot\cos\left(\varphi_3(260deg)\right)\right) \ldots$$
$$+ M_{\Phi 3}(260deg)$$

$x_{26}:= -959.897$

$$-F_{34x}(260deg)\cdot\cos\left(\varphi_3(260deg)\right) + F_{34y}(260deg)\cdot\sin\left(\varphi_3(260deg)\right) \ldots = \left(-1.83\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(260deg)\right)\right) - \Phi_{3x}(260deg)\cdot\cos\left(\varphi_3(260deg)\right) + \Phi_{3y}(260deg)\cdot\sin\left(\varphi_3(260deg)\right)$$

$x_{26a}:= -1830$

$$F_{34x}(270deg)\cdot\sin\left(\varphi_3(270deg)\right) + F_{34y}(270deg)\cdot\cos\left(\varphi_3(270deg)\right) \ldots = \left(-1.396\times 10^3\right)$$
$$+ 0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(270deg)\right) + \Phi_{3x}(270deg)\cdot\sin\left(\varphi_3(270deg)\right) + \Phi_{3y}(270deg)\cdot\cos\left(\varphi_3(270deg)\right)\right) \ldots$$
$$+ M_{\Phi 3}(270deg)$$

$x_{27}:= -1396$

$$-F_{34x}(270deg)\cdot\cos\left(\varphi_3(270deg)\right) + F_{34y}(270deg)\cdot\sin\left(\varphi_3(270deg)\right) \ldots = \left(-2.025\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(270deg)\right)\right) - \Phi_{3x}(270deg)\cdot\cos\left(\varphi_3(270deg)\right) + \Phi_{3y}(270deg)\cdot\sin\left(\varphi_3(270deg)\right)$$

$x_{27a}:= -2025$

$$F_{34x}(280deg)\cdot\sin\left(\varphi_3(280deg)\right) + F_{34y}(280deg)\cdot\cos\left(\varphi_3(280deg)\right) \ldots = \left(-1.528\times 10^3\right)$$
$$+ 0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(280deg)\right) + \Phi_{3x}(280deg)\cdot\sin\left(\varphi_3(280deg)\right) + \Phi_{3y}(280deg)\cdot\cos\left(\varphi_3(280deg)\right)\right) \ldots$$
$$+ M_{\Phi 3}(280deg)$$

$x_{28}:= -1528$

$$-F_{34x}(280deg)\cdot\cos\left(\varphi_3(280deg)\right) + F_{34y}(280deg)\cdot\sin\left(\varphi_3(280deg)\right) \ldots = \left(-2.328\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(280deg)\right)\right) - \Phi_{3x}(280deg)\cdot\cos\left(\varphi_3(280deg)\right) + \Phi_{3y}(280deg)\cdot\sin\left(\varphi_3(280deg)\right)$$

$x_{28a}:= -2328$

$$F_{34x}(290deg)\cdot\sin\left(\varphi_3(290deg)\right) + F_{34y}(290deg)\cdot\cos\left(\varphi_3(290deg)\right) \ldots = \left(-1.459\times 10^3\right)$$
$$+ 0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(290deg)\right) + \Phi_{3x}(290deg)\cdot\sin\left(\varphi_3(290deg)\right) + \Phi_{3y}(290deg)\cdot\cos\left(\varphi_3(290deg)\right)\right) \ldots$$
$$+ M_{\Phi 3}(290deg)$$

$x_{29}:= -1459$

$$-F_{34x}(290deg)\cdot\cos\left(\varphi_3(290deg)\right) + F_{34y}(290deg)\cdot\sin\left(\varphi_3(290deg)\right) \ldots = \left(-2.603\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(290deg)\right)\right) - \Phi_{3x}(290deg)\cdot\cos\left(\varphi_3(290deg)\right) + \Phi_{3y}(290deg)\cdot\sin\left(\varphi_3(290deg)\right)$$

$x_{29a}:= -2603$

$$F_{34x}(300deg)\cdot\sin\left(\varphi_3(300deg)\right) + F_{34y}(300deg)\cdot\cos\left(\varphi_3(300deg)\right) \ldots = \left(-1.293\times 10^3\right)$$
$$+ 0.5\cdot\left(G_3\cdot\cos\left(\varphi_3(300deg)\right) + \Phi_{3x}(300deg)\cdot\sin\left(\varphi_3(300deg)\right) + \Phi_{3y}(300deg)\cdot\cos\left(\varphi_3(300deg)\right)\right) \ldots$$
$$+ M_{\Phi 3}(300deg)$$

$x_{30}:= -1293$

$$-F_{34x}(300deg)\cdot\cos\left(\varphi_3(300deg)\right) + F_{34y}(300deg)\cdot\sin\left(\varphi_3(300deg)\right) \ldots = \left(-2.798\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(300deg)\right)\right) - \Phi_{3x}(300deg)\cdot\cos\left(\varphi_3(300deg)\right) + \Phi_{3y}(300deg)\cdot\sin\left(\varphi_3(300deg)\right)$$

$x_{30a}:= -2798$

$F_{34x}(310deg)\cdot\sin(\varphi_3(310deg)) + F_{34y}(310deg)\cdot\cos(\varphi_3(310deg)) \ldots = (-1.004\times 10^3)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(310deg)) + \Phi_{3x}(310deg)\cdot\sin(\delta_3(310deg)) + \Phi_{4y}(310deg)\cdot\cos(\varphi_3(310deg))) \ldots$
$+ M_{\Phi 4}(310deg)$

$x_{31} := -1004$

$-F_{34x}(310deg)\cdot\cos(\varphi_3(310deg)) + F_{34y}(310deg)\cdot\sin(\varphi_3(310deg)) \ldots = (-2.91\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(310deg))) - \Phi_{3x}(310deg)\cdot\cos(\varphi_3(310deg)) + \Phi_{3y}(310deg)\cdot\sin(\varphi_3(310deg))$

$x_{31a} := -2910$

$F_{34x}(320deg)\cdot\sin(\varphi_3(320deg)) + F_{34y}(320deg)\cdot\cos(\varphi_3(320deg)) \ldots = (-933.523)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(320deg)) + \Phi_{3x}(320deg)\cdot\sin(\varphi_3(320deg)) + \Phi_{3y}(320deg)\cdot\cos(\varphi_3(320deg))) \ldots$
$+ M_{\Phi 3}(320deg)$

$x_{32} := -933.523$

$-F_{34x}(320deg)\cdot\cos(\varphi_3(320deg)) + F_{34y}(320deg)\cdot\sin(\varphi_3(320deg)) \ldots = (-2.961\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(320deg))) - \Phi_{3x}(320deg)\cdot\cos(\varphi_3(320deg)) + \Phi_{3y}(320deg)\cdot\sin(\varphi_3(320deg))$

$x_{32a} := -2961$

$F_{34x}(330deg)\cdot\sin(\varphi_3(330deg)) + F_{34y}(330deg)\cdot\cos(\varphi_3(330deg)) \ldots = (-796.723)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(330deg)) + \Phi_{3x}(330deg)\cdot\sin(\varphi_3(330deg)) + \Phi_{3y}(330deg)\cdot\cos(\varphi_3(330deg))) \ldots$
$+ M_{\Phi 3}(330deg)$

$x_{33} := -796.723$

$-F_{34x}(330deg)\cdot\cos(\varphi_3(330deg)) + F_{34y}(330deg)\cdot\sin(\varphi_3(330deg)) \ldots = (-2.976\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(330deg))) - \Phi_{3x}(330deg)\cdot\cos(\varphi_3(330deg)) + \Phi_{3y}(330deg)\cdot\sin(\varphi_3(330deg))$

$x_{33a} := -2976$

$F_{34x}(340deg)\cdot\sin(\varphi_3(340deg)) + F_{34y}(340deg)\cdot\cos(\varphi_3(340deg)) \ldots = (-699.011)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(340deg)) + \Phi_{3x}(340deg)\cdot\sin(\varphi_3(340deg)) + \Phi_{3y}(340deg)\cdot\cos(\varphi_3(340deg))) \ldots$
$+ M_{\Phi 3}(340deg)$

$x_{34} := -699.011$

$-F_{34x}(340deg)\cdot\cos(\varphi_3(340deg)) + F_{34y}(340deg)\cdot\sin(\delta_3(340deg)) \ldots = (-2.426\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(340deg))) - \Phi_{3x}(340deg)\cdot\cos(\varphi_3(340deg)) + \Phi_{3y}(340deg)\cdot\sin(\varphi_3(340deg))$

$x_{34a} := -2426$

$F_{34x}(350deg)\cdot\sin(\varphi_3(350deg)) + F_{34y}(350deg)\cdot\cos(\varphi_3(350deg)) \ldots = (-638.926)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(350deg)) + \Phi_{3x}(350deg)\cdot\sin(\varphi_3(350deg)) + \Phi_{3y}(350deg)\cdot\cos(\varphi_3(350deg))) \ldots$
$+ M_{\Phi 3}(350deg)$

$x_{35} := -638.926$

$-F_{34x}(350deg)\cdot\cos(\varphi_3(350deg)) + F_{34y}(350deg)\cdot\sin(\varphi_3(350deg)) \ldots = (-2.958\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(350deg))) - \Phi_{3x}(350deg)\cdot\cos(\varphi_3(350deg)) + \Phi_{3y}(350deg)\cdot\sin(\varphi_3(350deg))$

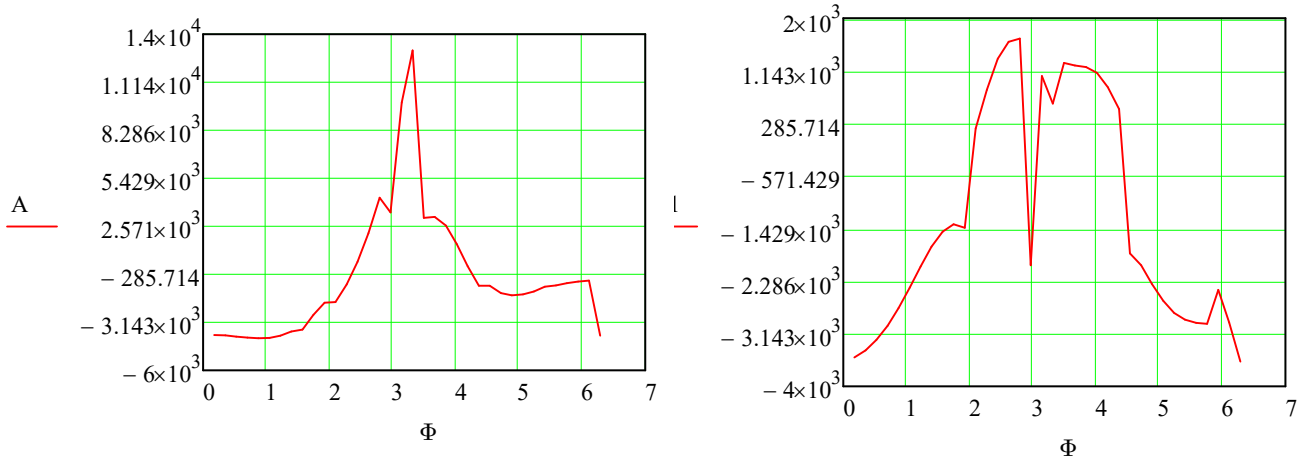
$x_{35a} := -2958$

$F_{34x}(360deg)\cdot\sin(\varphi_3(360deg)) + F_{34y}(360deg)\cdot\cos(\varphi_3(360deg)) \ldots = (-3.915\times 10^3)$
$+ 0.5\cdot(G_3\cdot\cos(\varphi_3(360deg)) + \Phi_{3x}(360deg)\cdot\sin(\varphi_3(360deg)) + \Phi_{3y}(360deg)\cdot\cos(\varphi_3(360deg))) \ldots$
$+ M_{\Phi 3}(360deg)$

$x_{36} := -3915$

$-F_{34x}(360deg)\cdot\cos(\varphi_3(360deg)) + F_{34y}(360deg)\cdot\sin(\varphi_3(360deg)) \ldots = (-3.591\times 10^3)$
$+ (-G_3\cdot\sin(\varphi_3(360deg))) - \Phi_{3x}(360deg)\cdot\cos(\varphi_3(360deg)) + \Phi_{3y}(360deg)\cdot\sin(\varphi_3(360deg))$

$x_{36a} := -3591$



$$F_{34x}(191deg)\cdot\sin\left(\varphi_3(191deg)\right) - F_{34y}(191deg)\cdot\cos\left(\varphi_3(191deg)\right) \ldots = \left(1.333\times 10^4\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(191deg)\right) + \Phi_{3x}(191deg)\cdot\sin\left(\varphi_3(191deg)\right)\right) - \Phi_{3y}(191deg)\cdot\cos\left(\varphi_3(191deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(191deg)$$

$$F_{34x}(192deg)\cdot\sin\left(\varphi_3(192deg)\right) - F_{34y}(192deg)\cdot\cos\left(\varphi_3(192deg)\right) \ldots = \left(1.36\times 10^4\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(192deg)\right) + \Phi_{3x}(192deg)\cdot\sin\left(\varphi_3(192deg)\right)\right) - \Phi_{3y}(192deg)\cdot\cos\left(\varphi_3(192deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(192deg)$$

$$F_{34x}(193deg)\cdot\sin\left(\varphi_3(193deg)\right) - F_{34y}(193deg)\cdot\cos\left(\varphi_3(193deg)\right) \ldots = \left(1.385\times 10^4\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(193deg)\right) + \Phi_{3x}(193deg)\cdot\sin\left(\varphi_3(193deg)\right)\right) - \Phi_{3y}(193deg)\cdot\cos\left(\varphi_3(193deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(193deg)$$

$$F_{34x}(194deg)\cdot\sin\left(\varphi_3(194deg)\right) - F_{34y}(194deg)\cdot\cos\left(\varphi_3(194deg)\right) \ldots = \left(2.834\times 10^3\right)$$
$$+ 0.5\cdot\left[\left(-G_3\cdot\sin\left(\varphi_3(194deg)\right) + \Phi_{3x}(194deg)\cdot\sin\left(\varphi_3(194deg)\right)\right) - \Phi_{3y}(194deg)\cdot\cos\left(\varphi_3(194deg)\right)\right] \ldots$$
$$+ M_{\Phi 3}(194deg)$$

$$-F_{34x}(1deg)\cdot\cos\left(\varphi_3(1deg)\right) + F_{34y}(1deg)\cdot\sin\left(\varphi_3(1deg)\right) \ldots = \left(-3.586\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(1deg)\right)\right) - \Phi_{3x}(1deg)\cdot\cos\left(\varphi_3(1deg)\right) + \Phi_{3y}(1deg)\cdot\sin\left(\varphi_3(1deg)\right)$$

$$-F_{34x}(359deg)\cdot\cos\left(\varphi_3(359deg)\right) + F_{34y}(359deg)\cdot\sin\left(\varphi_3(359deg)\right) \ldots = \left(-3.595\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(359deg)\right)\right) - \Phi_{3x}(359deg)\cdot\cos\left(\varphi_3(359deg)\right) + \Phi_{3y}(359deg)\cdot\sin\left(\varphi_3(359deg)\right)$$

$$-F_{34x}(358deg)\cdot\cos\left(\varphi_3(358deg)\right) + F_{34y}(358deg)\cdot\sin\left(\varphi_3(358deg)\right) \ldots = \left(-3.598\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(358deg)\right)\right) - \Phi_{3x}(358deg)\cdot\cos\left(\varphi_3(358deg)\right) + \Phi_{3y}(358deg)\cdot\sin\left(\varphi_3(358deg)\right)$$

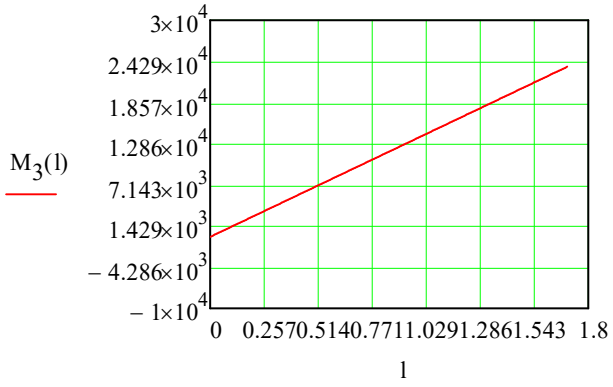
$$-F_{34x}(357deg)\cdot\cos\left(\varphi_3(357deg)\right) + F_{34y}(357deg)\cdot\sin\left(\varphi_3(357deg)\right) \ldots = \left(-2.947\times 10^3\right)$$
$$+ \left(-G_3\cdot\sin\left(\varphi_3(357deg)\right)\right) - \Phi_{3x}(357deg)\cdot\cos\left(\varphi_3(357deg)\right) + \Phi_{3y}(357deg)\cdot\sin\left(\varphi_3(357deg)\right)$$

$N_3 := 3598$

$F_{34x}(193deg) = \left(1.285 \times 10^{4}\right)$ $F_{34y}(193deg) = \left(-6.039 \times 10^{3}\right)$

$$M_3(l) := 12850 \cdot l \cdot \sin\left(\varphi_3(193deg)\right) + 6039 \cdot l \cdot \cos\left(\varphi_3(193deg)\right) \ldots + 0.5l \cdot \left[\left(-G_3 \cdot \sin\left(\varphi_3(193deg)\right) + \Phi_{3x}(193deg) \cdot \sin\left(\varphi_3(193deg)\right)\right) - \Phi_{3y}(193deg) \cdot \cos\left(\varphi_3(193deg)\right)\right] \ldots + M_{\Phi 3}(193deg)$$

$l := 0, 0.01 .. 1.7$



$M_{3max} := \left|M_3(1.7)\right| = 2.358 \times 10^{4}$

Условие на сжатие:G.t.>N/A

$$D_3 := \sqrt{\frac{4N_3}{\pi \cdot G_t}} = 4.119 \times 10^{-3} \text{ м}$$

Условие на изгиб: G.t>M.4max/W.p

$D_3 := \sqrt[3]{\frac{16M_{3max}}{\pi \cdot G_t}} = 0.076$ по Ra40 $D_3 := 0.075$ м

$$J_{S3} := \frac{m_3 \cdot \left(l_{CD}^{2} + 3\frac{D_3^{2}}{4}\right)}{12} = 38.59 \text{ кг} \cdot \text{м}^2$$

$$m_3 := \rho \cdot \pi \frac{D_3^{2} \cdot l_{CD}}{4} = 58.95(\text{кг}$$

Для звена 2:

$-F_{23x}(10deg) \cdot \sin\left(\varphi_2(10deg)\right) + F_{23y}(10deg) \cdot \cos\left(\varphi_2(10deg)\right) \ldots = (-0.143)$
$+ 0.5\left(-G_2 \cdot \cos\left(\varphi_2(10deg)\right) - \Phi_{2x}(10deg) \cdot \sin\left(\varphi_2(10deg)\right) + \Phi_{2y}(10deg) \cdot \cos\left(\varphi_2(10deg)\right)\right) + M_{\Phi 2}(10deg)$

$x_1 := -0.143$

$F_{23x}(10deg) \cdot \cos\left(\varphi_2(10deg)\right) + F_{23y}(10deg) \cdot \sin\left(\varphi_2(10deg)\right) \ldots = \left(-8.606 \times 10^{3}\right)$
$+ \left(-G_2 \cdot \sin\left(\varphi_2(10deg)\right)\right) + \Phi_{2x}(10deg) \cdot \cos\left(\varphi_2(10deg)\right) + \Phi_{2y}(10deg) \cdot \sin\left(\varphi_2(10deg)\right)$

$x_{1a} := -8606$

$-F_{23x}(20deg) \cdot \sin\left(\varphi_2(20deg)\right) + F_{23y}(20deg) \cdot \cos\left(\varphi_2(20deg)\right) \ldots = (-0.477)$
$+ 0.5\left(-G_2 \cdot \cos\left(\varphi_2(20deg)\right) - \Phi_{2x}(20deg) \cdot \sin\left(\varphi_2(20deg)\right) + \Phi_{2y}(20deg) \cdot \cos\left(\varphi_2(20deg)\right)\right) + M_{\Phi 2}(20deg)$

$x_2 := -0.477$

$F_{23x}(20deg) \cdot \cos\left(\varphi_2(20deg)\right) + F_{23y}(20deg) \cdot \sin\left(\varphi_2(20deg)\right) \ldots = \left(-8.497 \times 10^{3}\right)$
$+ \left(-G_2 \cdot \sin\left(\varphi_2(20deg)\right)\right) + \Phi_{2x}(20deg) \cdot \cos\left(\varphi_2(20deg)\right) + \Phi_{2y}(20deg) \cdot \sin\left(\varphi_2(20deg)\right)$

$x_{2a} := -8497$

$$-F_{23x}(30deg)\cdot\sin\left(\varphi_2(30deg)\right) + F_{23y}(30deg)\cdot\cos\left(\varphi_2(30deg)\right) \ldots = (-0.742)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(30deg)\right) - \Phi_{2x}(30deg)\cdot\sin\left(\varphi_2(30deg)\right) + \Phi_{2y}(30deg)\cdot\cos\left(\varphi_2(30deg)\right)\right) + M_{\Phi 2}(30deg)$$

$x_3 := -0.742$

$$F_{23x}(30deg)\cdot\cos\left(\varphi_2(30deg)\right) + F_{23y}(30deg)\cdot\sin\left(\varphi_2(30deg)\right) \ldots = \left(-8.409\times 10^3\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(30deg)\right)\right) + \Phi_{2x}(30deg)\cdot\cos\left(\varphi_2(30deg)\right) + \Phi_{2y}(30deg)\cdot\sin\left(\varphi_2(30deg)\right)$$

$x_{3a} := -8409$

$$-F_{23x}(40deg)\cdot\sin\left(\varphi_2(40deg)\right) + F_{23y}(40deg)\cdot\cos\left(\varphi_2(40deg)\right) \ldots = (-0.938)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(40deg)\right) - \Phi_{2x}(40deg)\cdot\sin\left(\varphi_2(40deg)\right) + \Phi_{2y}(40deg)\cdot\cos\left(\varphi_2(40deg)\right)\right) + M_{\Phi 2}(40deg)$$

$x_4 := -0.938$

$$F_{23x}(40deg)\cdot\cos\left(\varphi_2(40deg)\right) + F_{23y}(40deg)\cdot\sin\left(\varphi_2(40deg)\right) \ldots = \left(-8.314\times 10^3\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(40deg)\right)\right) + \Phi_{2x}(40deg)\cdot\cos\left(\varphi_2(40deg)\right) + \Phi_{2y}(40deg)\cdot\sin\left(\varphi_2(40deg)\right)$$

$x_{4a} := -8314$

$$-F_{23x}(50deg)\cdot\sin\left(\varphi_2(50deg)\right) + F_{23y}(50deg)\cdot\cos\left(\varphi_2(50deg)\right) \ldots = (-1.069)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(50deg)\right) - \Phi_{2x}(50deg)\cdot\sin\left(\varphi_2(50deg)\right) + \Phi_{2y}(50deg)\cdot\cos\left(\varphi_2(50deg)\right)\right) + M_{\Phi 2}(50deg)$$

$x_5 := -1.069$

$$F_{23x}(50deg)\cdot\cos\left(\varphi_2(50deg)\right) + F_{23y}(50deg)\cdot\sin\left(\varphi_2(50deg)\right) \ldots = \left(-8.189\times 10^3\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(50deg)\right)\right) + \Phi_{2x}(50deg)\cdot\cos\left(\varphi_2(50deg)\right) + \Phi_{2y}(50deg)\cdot\sin\left(\varphi_2(50deg)\right)$$

$x_{5a} := -8189$

$$-F_{23x}(60deg)\cdot\sin\left(\varphi_2(60deg)\right) + F_{23y}(60deg)\cdot\cos\left(\varphi_2(60deg)\right) \ldots = (-1.143)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(60deg)\right) - \Phi_{2x}(60deg)\cdot\sin\left(\varphi_2(60deg)\right) + \Phi_{2y}(60deg)\cdot\cos\left(\varphi_2(60deg)\right)\right) + M_{\Phi 2}(60deg)$$

$x_6 := -1.143$

$$F_{23x}(60deg)\cdot\cos\left(\varphi_2(60deg)\right) + F_{23y}(60deg)\cdot\sin\left(\varphi_2(60deg)\right) \ldots = \left(-8.004\times 10^3\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(60deg)\right)\right) + \Phi_{2x}(60deg)\cdot\cos\left(\varphi_2(60deg)\right) + \Phi_{2y}(60deg)\cdot\sin\left(\varphi_2(60deg)\right)$$

$x_{6a} := -8004$

$$-F_{23x}(70deg)\cdot\sin\left(\varphi_2(70deg)\right) + F_{23y}(70deg)\cdot\cos\left(\varphi_2(70deg)\right) \ldots = (-1.17)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(70deg)\right) - \Phi_{2x}(70deg)\cdot\sin\left(\varphi_2(70deg)\right) + \Phi_{2y}(70deg)\cdot\cos\left(\varphi_2(70deg)\right)\right) + M_{\Phi 2}(70deg)$$

$x_7 := -1.17$

$$F_{23x}(70deg)\cdot\cos\left(\varphi_2(70deg)\right) + F_{23y}(70deg)\cdot\sin\left(\varphi_2(70deg)\right) \ldots = \left(-7.723\times 10^3\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(70deg)\right)\right) + \Phi_{2x}(70deg)\cdot\cos\left(\varphi_2(70deg)\right) + \Phi_{2y}(70deg)\cdot\sin\left(\varphi_2(70deg)\right)$$

$x_{7a} := -7723$

$$-F_{23x}(80deg)\cdot\sin\left(\varphi_2(80deg)\right) + F_{23y}(80deg)\cdot\cos\left(\varphi_2(80deg)\right) \ldots = (-1.166)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(80deg)\right) - \Phi_{2x}(80deg)\cdot\sin\left(\varphi_2(80deg)\right) + \Phi_{2y}(80deg)\cdot\cos\left(\varphi_2(80deg)\right)\right) + M_{\Phi 2}(80deg)$$

$x_8 := -1.166$

$$F_{23x}(80deg)\cdot\cos\left(\varphi_2(80deg)\right) + F_{23y}(80deg)\cdot\sin\left(\varphi_2(80deg)\right) \ldots = \left(-7.294\times 10^3\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(80deg)\right)\right) + \Phi_{2x}(80deg)\cdot\cos\left(\varphi_2(80deg)\right) + \Phi_{2y}(80deg)\cdot\sin\left(\varphi_2(80deg)\right)$$

$x_{8a} := -7294$

$$-F_{23x}(90deg)\cdot\sin\left(\varphi_2(90deg)\right) + F_{23y}(90deg)\cdot\cos\left(\varphi_2(90deg)\right) \ldots = (-1.144)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(90deg)\right) - \Phi_{2x}(90deg)\cdot\sin\left(\varphi_2(90deg)\right) + \Phi_{2y}(90deg)\cdot\cos\left(\varphi_2(90deg)\right)\right) + M_{\Phi 2}(90deg)$$

$x_9 := -1.144$

$F_{23x}(90deg)\cdot\cos(\varphi_2(90deg)) + F_{23y}(90deg)\cdot\sin(\varphi_2(90deg)) \ldots = (-6.648\times 10^3)$
$+(-G_2\cdot\sin(\varphi_2(90deg))) + \Phi_{2x}(90deg)\cdot\cos(\varphi_2(90deg)) + \Phi_{2y}(90deg)\cdot\sin(\varphi_2(90deg))$

$x_{9a} := -6648$

$-F_{23x}(100deg)\cdot\sin(\varphi_2(100deg)) + F_{23y}(100deg)\cdot\cos(\varphi_2(100deg)) \ldots = (-1.121)$
$+0.5(-G_2\cdot\cos(\varphi_2(100deg)) - \Phi_{2x}(100deg)\cdot\sin(\varphi_2(100deg)) + \Phi_{2y}(100deg)\cdot\cos(\varphi_2(100deg))) + M_{\Phi 2}(100deg)$

$x_{10} := -1.121$

$F_{23x}(100deg)\cdot\cos(\varphi_2(100deg)) + F_{23y}(100deg)\cdot\sin(\varphi_2(100deg)) \ldots = (-5.701\times 10^3)$
$+(-G_2\cdot\sin(\varphi_2(100deg))) + \Phi_{2x}(100deg)\cdot\cos(\varphi_2(100deg)) + \Phi_{2y}(100deg)\cdot\sin(\varphi_2(100deg))$

$x_{10a} := -5701$

$-F_{23x}(110deg)\cdot\sin(\varphi_2(110deg)) + F_{23y}(110deg)\cdot\cos(\varphi_2(110deg)) \ldots = (-1.113)$
$+0.5(-G_2\cdot\cos(\varphi_2(110deg)) - \Phi_{2x}(110deg)\cdot\sin(\varphi_2(110deg)) + \Phi_{2y}(110deg)\cdot\cos(\varphi_2(110deg))) + M_{\Phi 2}(110deg)$

$x_{11} := -1.113$

$F_{23x}(110deg)\cdot\cos(\varphi_2(110deg)) + F_{23y}(110deg)\cdot\sin(\varphi_2(110deg)) \ldots = (-4.357\times 10^3)$
$+(-G_2\cdot\sin(\varphi_2(110deg))) + \Phi_{2x}(110deg)\cdot\cos(\varphi_2(110deg)) + \Phi_{2y}(110deg)\cdot\sin(\varphi_2(110deg))$

$x_{11a} := -4357$

$-F_{23x}(120deg)\cdot\sin(\varphi_2(120deg)) + F_{23y}(120deg)\cdot\cos(\varphi_2(120deg)) \ldots = (-1.139)$
$+0.5(-G_2\cdot\cos(\varphi_2(120deg)) - \Phi_{2x}(120deg)\cdot\sin(\varphi_2(120deg)) + \Phi_{2y}(120deg)\cdot\cos(\varphi_2(120deg))) + M_{\Phi 2}(120deg)$

$x_{12} := -1.139$

$F_{23x}(120deg)\cdot\cos(\varphi_2(120deg)) + F_{23y}(120deg)\cdot\sin(\varphi_2(120deg)) \ldots = (-2.505\times 10^3)$
$+(-G_2\cdot\sin(\varphi_2(120deg))) + \Phi_{2x}(120deg)\cdot\cos(\varphi_2(120deg)) + \Phi_{2y}(120deg)\cdot\sin(\varphi_2(120deg))$

$x_{12a} := -2505$

$-F_{23x}(130deg)\cdot\sin(\varphi_2(130deg)) + F_{23y}(130deg)\cdot\cos(\varphi_2(130deg)) \ldots = (-1.22)$
$+0.5(-G_2\cdot\cos(\varphi_2(130deg)) - \Phi_{2x}(130deg)\cdot\sin(\varphi_2(130deg)) + \Phi_{2y}(130deg)\cdot\cos(\varphi_2(130deg))) + M_{\Phi 2}(130deg)$

$x_{13} := -1.22$

$F_{23x}(130deg)\cdot\cos(\varphi_2(130deg)) + F_{23y}(130deg)\cdot\sin(\varphi_2(130deg)) \ldots = (-5.43)$
$+(-G_2\cdot\sin(\varphi_2(130deg))) + \Phi_{2x}(130deg)\cdot\cos(\varphi_2(130deg)) + \Phi_{2y}(130deg)\cdot\sin(\varphi_2(130deg))$

$x_{13a} := -5.43$

$-F_{23x}(140deg)\cdot\sin(\varphi_2(140deg)) + F_{23y}(140deg)\cdot\cos(\varphi_2(140deg)) \ldots = (-1.382)$
$+0.5(-G_2\cdot\cos(\varphi_2(140deg)) - \Phi_{2x}(140deg)\cdot\sin(\varphi_2(140deg)) + \Phi_{2y}(140deg)\cdot\cos(\varphi_2(140deg))) + M_{\Phi 2}(140deg)$

$x_{14} := -1.382$

$F_{23x}(140deg)\cdot\cos(\varphi_2(140deg)) + F_{23y}(140deg)\cdot\sin(\varphi_2(140deg)) \ldots = (3.349\times 10^3)$
$+(-G_2\cdot\sin(\varphi_2(140deg))) + \Phi_{2x}(140deg)\cdot\cos(\varphi_2(140deg)) + \Phi_{2y}(140deg)\cdot\sin(\varphi_2(140deg))$

$x_{14a} := 3349$

$-F_{23x}(150deg)\cdot\sin(\varphi_2(150deg)) + F_{23y}(150deg)\cdot\cos(\varphi_2(150deg)) \ldots = (-1.655)$
$+0.5(-G_2\cdot\cos(\varphi_2(150deg)) - \Phi_{2x}(150deg)\cdot\sin(\varphi_2(150deg)) + \Phi_{2y}(150deg)\cdot\cos(\varphi_2(150deg))) + M_{\Phi 2}(150deg)$

$x_{15} := -1.655$

$F_{23x}(150deg)\cdot\cos(\varphi_2(150deg)) + F_{23y}(150deg)\cdot\sin(\varphi_2(150deg)) \ldots = (7.87\times 10^3)$
$+(-G_2\cdot\sin(\varphi_2(150deg))) + \Phi_{2x}(150deg)\cdot\cos(\varphi_2(150deg)) + \Phi_{2y}(150deg)\cdot\sin(\varphi_2(150deg))$

$x_{15a} := 7870$

$$-F_{23x}(160deg)\cdot\sin\left(\varphi_2(160deg)\right) + F_{23y}(160deg)\cdot\cos\left(\varphi_2(160deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(160deg)\right) - \Phi_{2x}(160deg)\cdot\sin\left(\varphi_2(160deg)\right) + \Phi_{2y}(160deg)\cdot\cos\left(\varphi_2(160deg)\right)\right) + M_{\Phi 2}(160deg) = (-2.067)$$

$x_{16} := -2.067$

$$F_{23x}(160deg)\cdot\cos\left(\varphi_2(160deg)\right) + F_{23y}(160deg)\cdot\sin\left(\varphi_2(160deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(160deg)\right)\right) + \Phi_{2x}(160deg)\cdot\cos\left(\varphi_2(160deg)\right) + \Phi_{2y}(160deg)\cdot\sin\left(\varphi_2(160deg)\right) = \left(1.399\times 10^4\right)$$

$x_{16a} := 13990$

$$-F_{23x}(170deg)\cdot\sin\left(\varphi_2(170deg)\right) + F_{23y}(170deg)\cdot\cos\left(\varphi_2(170deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(170deg)\right) - \Phi_{2x}(170deg)\cdot\sin\left(\varphi_2(170deg)\right) + \Phi_{2y}(170deg)\cdot\cos\left(\varphi_2(170deg)\right)\right) + M_{\Phi 2}(170deg) = (-2.622)$$

$x_{17} := -2.622$

$$F_{23x}(170deg)\cdot\cos\left(\varphi_2(170deg)\right) + F_{23y}(170deg)\cdot\sin\left(\varphi_2(170deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(170deg)\right)\right) + \Phi_{2x}(170deg)\cdot\cos\left(\varphi_2(170deg)\right) + \Phi_{2y}(170deg)\cdot\sin\left(\varphi_2(170deg)\right) = \left(2.221\times 10^4\right)$$

$x_{17a} := 22210$

$$-F_{23x}(180deg)\cdot\sin\left(\varphi_2(180deg)\right) + F_{23y}(180deg)\cdot\cos\left(\varphi_2(180deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(180deg)\right) - \Phi_{2x}(180deg)\cdot\sin\left(\varphi_2(180deg)\right) + \Phi_{2y}(180deg)\cdot\cos\left(\varphi_2(180deg)\right)\right) + M_{\Phi 2}(180deg) = (-3.243)$$

$x_{18} := -3.243$

$$F_{23x}(180deg)\cdot\cos\left(\varphi_2(180deg)\right) + F_{23y}(180deg)\cdot\sin\left(\varphi_2(180deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(180deg)\right)\right) + \Phi_{2x}(180deg)\cdot\cos\left(\varphi_2(180deg)\right) + \Phi_{2y}(180deg)\cdot\sin\left(\varphi_2(180deg)\right) = \left(3.276\times 10^4\right)$$

$x_{18a} := 32760$

$$-F_{23x}(190deg)\cdot\sin\left(\varphi_2(190deg)\right) + F_{23y}(190deg)\cdot\cos\left(\varphi_2(190deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(190deg)\right) - \Phi_{2x}(190deg)\cdot\sin\left(\varphi_2(190deg)\right) + \Phi_{2y}(190deg)\cdot\cos\left(\varphi_2(190deg)\right)\right) + M_{\Phi 2}(190deg) = (-3.684)$$

$x_{19} := -3.684$

$$F_{23x}(190deg)\cdot\cos\left(\varphi_2(190deg)\right) + F_{23y}(190deg)\cdot\sin\left(\varphi_2(190deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(190deg)\right)\right) + \Phi_{2x}(190deg)\cdot\cos\left(\varphi_2(190deg)\right) + \Phi_{2y}(190deg)\cdot\sin\left(\varphi_2(190deg)\right) = \left(4.461\times 10^4\right)$$

$x_{19a} := 44610$

$$-F_{23x}(200deg)\cdot\sin\left(\varphi_2(200deg)\right) + F_{23y}(200deg)\cdot\cos\left(\varphi_2(200deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(200deg)\right) - \Phi_{2x}(200deg)\cdot\sin\left(\varphi_2(200deg)\right) + \Phi_{2y}(200deg)\cdot\cos\left(\varphi_2(200deg)\right)\right) + M_{\Phi 2}(200deg) = (-3.684)$$

$x_{20} := -3.684$

$$F_{23x}(200deg)\cdot\cos\left(\varphi_2(200deg)\right) + F_{23y}(200deg)\cdot\sin\left(\varphi_2(200deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(200deg)\right)\right) + \Phi_{2x}(200deg)\cdot\cos\left(\varphi_2(200deg)\right) + \Phi_{2y}(200deg)\cdot\sin\left(\varphi_2(200deg)\right) = \left(1.424\times 10^4\right)$$

$x_{20a} := 14240$

$$-F_{23x}(210deg)\cdot\sin\left(\varphi_2(210deg)\right) + F_{23y}(210deg)\cdot\cos\left(\varphi_2(210deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(210deg)\right) - \Phi_{2x}(210deg)\cdot\sin\left(\varphi_2(210deg)\right) + \Phi_{2y}(210deg)\cdot\cos\left(\varphi_2(210deg)\right)\right) + M_{\Phi 2}(210deg) = (-3.025)$$

$x_{21} := -3.025$

$$F_{23x}(210deg)\cdot\cos\left(\varphi_2(210deg)\right) + F_{23y}(210deg)\cdot\sin\left(\varphi_2(210deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(210deg)\right)\right) + \Phi_{2x}(210deg)\cdot\cos\left(\varphi_2(210deg)\right) + \Phi_{2y}(210deg)\cdot\sin\left(\varphi_2(210deg)\right) = \left(1.49\times 10^4\right)$$

$x_{21a} := 14900$

$$-F_{23x}(220deg)\cdot\sin\left(\varphi_2(220deg)\right) + F_{23y}(220deg)\cdot\cos\left(\varphi_2(220deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(220deg)\right) - \Phi_{2x}(220deg)\cdot\sin\left(\varphi_2(220deg)\right) + \Phi_{2y}(220deg)\cdot\cos\left(\varphi_2(220deg)\right)\right) + M_{\Phi 2}(220deg) = (-1.576)$$

$x_{22} := -1.576$

$$F_{23x}(220deg)\cdot\cos\left(\varphi_2(220deg)\right) + F_{23y}(220deg)\cdot\sin\left(\varphi_2(220deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(220deg)\right)\right) + \Phi_{2x}(220deg)\cdot\cos\left(\varphi_2(220deg)\right) + \Phi_{2y}(220deg)\cdot\sin\left(\varphi_2(220deg)\right) = \left(1.303\times 10^4\right)$$

$x_{22a} := 13030$

$$-F_{23x}(230deg)\cdot\sin\left(\varphi_2(230deg)\right) + F_{23y}(230deg)\cdot\cos\left(\varphi_2(230deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(230deg)\right) - \Phi_{2x}(230deg)\cdot\sin\left(\varphi_2(230deg)\right) + \Phi_{2y}(230deg)\cdot\cos\left(\varphi_2(230deg)\right)\right) + M_{\Phi 2}(230deg) = (0.308)$$

x_{23}:= 0.308

$$F_{23x}(230deg)\cdot\cos\left(\varphi_2(230deg)\right) + F_{23y}(230deg)\cdot\sin\left(\varphi_2(230deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(230deg)\right)\right) + \Phi_{2x}(230deg)\cdot\cos\left(\varphi_2(230deg)\right) + \Phi_{2y}(230deg)\cdot\sin\left(\varphi_2(230deg)\right) = \left(8.799\times 10^{3}\right)$$

x_{23a}:= 8799

$$-F_{23x}(240deg)\cdot\sin\left(\varphi_2(240deg)\right) + F_{23y}(240deg)\cdot\cos\left(\varphi_2(240deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(240deg)\right) - \Phi_{2x}(240deg)\cdot\sin\left(\varphi_2(240deg)\right) + \Phi_{2y}(240deg)\cdot\cos\left(\varphi_2(240deg)\right)\right) + M_{\Phi 2}(240deg) = (2.098)$$

x_{24}:= 2.098

$$F_{23x}(240deg)\cdot\cos\left(\varphi_2(240deg)\right) + F_{23y}(240deg)\cdot\sin\left(\varphi_2(240deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(240deg)\right)\right) + \Phi_{2x}(240deg)\cdot\cos\left(\varphi_2(240deg)\right) + \Phi_{2y}(240deg)\cdot\sin\left(\varphi_2(240deg)\right) = \left(3.757\times 10^{3}\right)$$

x_{24a}:= 3757

$$-F_{23x}(250deg)\cdot\sin\left(\varphi_2(250deg)\right) + F_{23y}(250deg)\cdot\cos\left(\varphi_2(250deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(250deg)\right) - \Phi_{2x}(250deg)\cdot\sin\left(\varphi_2(250deg)\right) + \Phi_{2y}(250deg)\cdot\cos\left(\varphi_2(250deg)\right)\right) + M_{\Phi 2}(250deg) = (3.456)$$

x_{25}:= 3.456

$$F_{23x}(250deg)\cdot\cos\left(\varphi_2(250deg)\right) + F_{23y}(250deg)\cdot\sin\left(\varphi_2(250deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(250deg)\right)\right) + \Phi_{2x}(250deg)\cdot\cos\left(\varphi_2(250deg)\right) + \Phi_{2y}(250deg)\cdot\sin\left(\varphi_2(250deg)\right) = (-468.655)$$

x_{25a}:= −468.655

$$-F_{23x}(260deg)\cdot\sin\left(\varphi_2(260deg)\right) + F_{23y}(260deg)\cdot\cos\left(\varphi_2(260deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(260deg)\right) - \Phi_{2x}(260deg)\cdot\sin\left(\varphi_2(260deg)\right) + \Phi_{2y}(260deg)\cdot\cos\left(\varphi_2(260deg)\right)\right) + M_{\Phi 2}(260deg) = (4.281)$$

x_{26}:= 4.281

$$F_{23x}(260deg)\cdot\cos\left(\varphi_2(260deg)\right) + F_{23y}(260deg)\cdot\sin\left(\varphi_2(260deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(260deg)\right)\right) + \Phi_{2x}(260deg)\cdot\cos\left(\varphi_2(260deg)\right) + \Phi_{2y}(260deg)\cdot\sin\left(\varphi_2(260deg)\right) = \left(-3.198\times 10^{3}\right)$$

x_{26a}:= −3198

$$-F_{23x}(270deg)\cdot\sin\left(\varphi_2(270deg)\right) + F_{23y}(270deg)\cdot\cos\left(\varphi_2(270deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(270deg)\right) - \Phi_{2x}(270deg)\cdot\sin\left(\varphi_2(270deg)\right) + \Phi_{2y}(270deg)\cdot\cos\left(\varphi_2(270deg)\right)\right) + M_{\Phi 2}(270deg) = (4.597)$$

x_{27}:= 4.597

$$F_{23x}(270deg)\cdot\cos\left(\varphi_2(270deg)\right) + F_{23y}(270deg)\cdot\sin\left(\varphi_2(270deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(270deg)\right)\right) + \Phi_{2x}(270deg)\cdot\cos\left(\varphi_2(270deg)\right) + \Phi_{2y}(270deg)\cdot\sin\left(\varphi_2(270deg)\right) = \left(-4.589\times 10^{3}\right)$$

x_{27a}:= −4589

$$-F_{23x}(280deg)\cdot\sin\left(\varphi_2(280deg)\right) + F_{23y}(280deg)\cdot\cos\left(\varphi_2(280deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(280deg)\right) - \Phi_{2x}(280deg)\cdot\sin\left(\varphi_2(280deg)\right) + \Phi_{2y}(280deg)\cdot\cos\left(\varphi_2(280deg)\right)\right) + M_{\Phi 2}(280deg) = (4.501)$$

x_{28}:= 4.501

$$F_{23x}(280deg)\cdot\cos\left(\varphi_2(280deg)\right) + F_{23y}(280deg)\cdot\sin\left(\varphi_2(280deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(280deg)\right)\right) + \Phi_{2x}(280deg)\cdot\cos\left(\varphi_2(280deg)\right) + \Phi_{2y}(280deg)\cdot\sin\left(\varphi_2(280deg)\right) = \left(-5.115\times 10^{3}\right)$$

x_{28a}:= −5115

$$-F_{23x}(290deg)\cdot\sin\left(\varphi_2(290deg)\right) + F_{23y}(290deg)\cdot\cos\left(\varphi_2(290deg)\right) \ldots + 0.5\left(-G_2\cdot\cos\left(\varphi_2(290deg)\right) - \Phi_{2x}(290deg)\cdot\sin\left(\varphi_2(290deg)\right) + \Phi_{2y}(290deg)\cdot\cos\left(\varphi_2(290deg)\right)\right) + M_{\Phi 2}(290deg) = (4.123)$$

x_{29}:= 4.123

$$F_{23x}(290deg)\cdot\cos\left(\varphi_2(290deg)\right) + F_{23y}(290deg)\cdot\sin\left(\varphi_2(290deg)\right) \ldots + \left(-G_2\cdot\sin\left(\varphi_2(290deg)\right)\right) + \Phi_{2x}(290deg)\cdot\cos\left(\varphi_2(290deg)\right) + \Phi_{2y}(290deg)\cdot\sin\left(\varphi_2(290deg)\right) = \left(-5.194\times 10^{3}\right)$$

$x_{29a} := -5194$

$$-F_{23x}(300deg)\cdot\sin\left(\varphi_2(300deg)\right) + F_{23y}(300deg)\cdot\cos\left(\varphi_2(300deg)\right) \ldots = (3.584)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(300deg)\right) - \Phi_{2x}(300deg)\cdot\sin\left(\varphi_2(300deg)\right) + \Phi_{2y}(300deg)\cdot\cos\left(\varphi_2(300deg)\right)\right) + M_{\Phi 2}(300deg)$$

$x_{30} := 3.584$

$$F_{23x}(300deg)\cdot\cos\left(\varphi_2(300deg)\right) + F_{23y}(300deg)\cdot\sin\left(\varphi_2(300deg)\right) \ldots = \left(-5.09\times 10^{3}\right)$$
$$+ \left(-G_2\cdot\sin\left(\varphi_2(300deg)\right)\right) + \Phi_{2x}(300deg)\cdot\cos\left(\varphi_2(300deg)\right) + \Phi_{2y}(300deg)\cdot\sin\left(\varphi_2(300deg)\right)$$

$x_{30a} := -5090$

$$-F_{23x}(310deg)\cdot\sin\left(\varphi_2(310deg)\right) + F_{23y}(310deg)\cdot\cos\left(\varphi_2(310deg)\right) \ldots = (2.976)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(310deg)\right) - \Phi_{2x}(310deg)\cdot\sin\left(\varphi_2(310deg)\right) + \Phi_{2y}(310deg)\cdot\cos\left(\varphi_2(310deg)\right)\right) + M_{\Phi 2}(310deg)$$

$x_{31} := 2.976$

$$F_{23x}(310deg)\cdot\cos\left(\varphi_2(310deg)\right) + F_{23y}(310deg)\cdot\sin\left(\varphi_2(310deg)\right) \ldots = \left(-4.934\times 10^{3}\right)$$
$$+ \left(-G_2\cdot\sin\left(\varphi_2(310deg)\right)\right) + \Phi_{2x}(310deg)\cdot\cos\left(\varphi_2(310deg)\right) + \Phi_{2y}(310deg)\cdot\sin\left(\varphi_2(310deg)\right)$$

$x_{31a} := -4934$

$$-F_{23x}(320deg)\cdot\sin\left(\varphi_2(320deg)\right) + F_{23y}(320deg)\cdot\cos\left(\varphi_2(320deg)\right) \ldots = (2.358)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(320deg)\right) - \Phi_{2x}(320deg)\cdot\sin\left(\varphi_2(320deg)\right) + \Phi_{2y}(320deg)\cdot\cos\left(\varphi_2(320deg)\right)\right) + M_{\Phi 2}(320deg)$$

$x_{32} := 2.358$

$$F_{23x}(320deg)\cdot\cos\left(\varphi_2(320deg)\right) + F_{23y}(320deg)\cdot\sin\left(\varphi_2(320deg)\right) \ldots = \left(-4.782\times 10^{3}\right)$$
$$+ \left(-G_2\cdot\sin\left(\varphi_2(320deg)\right)\right) + \Phi_{2x}(320deg)\cdot\cos\left(\varphi_2(320deg)\right) + \Phi_{2y}(320deg)\cdot\sin\left(\varphi_2(320deg)\right)$$

$x_{32a} := -4782$

$$-F_{23x}(330deg)\cdot\sin\left(\varphi_2(330deg)\right) + F_{23y}(330deg)\cdot\cos\left(\varphi_2(330deg)\right) \ldots = (1.764)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(330deg)\right) - \Phi_{2x}(330deg)\cdot\sin\left(\varphi_2(330deg)\right) + \Phi_{2y}(330deg)\cdot\cos\left(\varphi_2(330deg)\right)\right) + M_{\Phi 2}(330deg)$$

$x_{33} := 1.764$

$$F_{23x}(330deg)\cdot\cos\left(\varphi_2(330deg)\right) + F_{23y}(330deg)\cdot\sin\left(\varphi_2(330deg)\right) \ldots = \left(-4.651\times 10^{3}\right)$$
$$+ \left(-G_2\cdot\sin\left(\varphi_2(330deg)\right)\right) + \Phi_{2x}(330deg)\cdot\cos\left(\varphi_2(330deg)\right) + \Phi_{2y}(330deg)\cdot\sin\left(\varphi_2(330deg)\right)$$

$x_{33a} := -4651$

$$-F_{23x}(340deg)\cdot\sin\left(\varphi_2(340deg)\right) + F_{23y}(340deg)\cdot\cos\left(\varphi_2(340deg)\right) \ldots = (1.21)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(340deg)\right) - \Phi_{2x}(340deg)\cdot\sin\left(\varphi_2(340deg)\right) + \Phi_{2y}(340deg)\cdot\cos\left(\varphi_2(340deg)\right)\right) + M_{\Phi 2}(340deg)$$

$x_{34} := 1.21$

$$F_{23x}(340deg)\cdot\cos\left(\varphi_2(340deg)\right) + F_{23y}(340deg)\cdot\sin\left(\varphi_2(340deg)\right) \ldots = \left(-4.542\times 10^{3}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(340deg)\right)\right) + \Phi_{2x}(340deg)\cdot\cos\left(\varphi_2(340deg)\right) + \Phi_{2y}(340deg)\cdot\sin\left(\varphi_2(340deg)\right)$$

$x_{34a} := -4542$

$$-F_{23x}(350deg)\cdot\sin\left(\varphi_2(350deg)\right) + F_{23y}(350deg)\cdot\cos\left(\varphi_2(350deg)\right) \ldots = (0.708)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(350deg)\right) - \Phi_{2x}(350deg)\cdot\sin\left(\varphi_2(350deg)\right) + \Phi_{2y}(350deg)\cdot\cos\left(\varphi_2(350deg)\right)\right) + M_{\Phi 2}(350deg)$$

$x_{35} := 0.708$

$$F_{23x}(350deg)\cdot\cos\left(\varphi_2(350deg)\right) + F_{23y}(350deg)\cdot\sin\left(\varphi_2(350deg)\right) \ldots = \left(-4.447\times 10^{3}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(350deg)\right)\right) + \Phi_{2x}(350deg)\cdot\cos\left(\varphi_2(350deg)\right) + \Phi_{2y}(350deg)\cdot\sin\left(\varphi_2(350deg)\right)$$

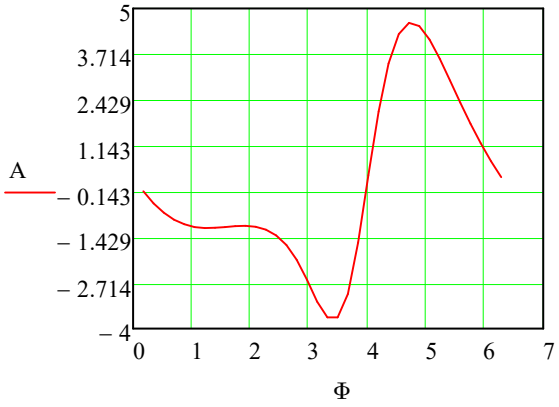
$x_{35a} := -4447$

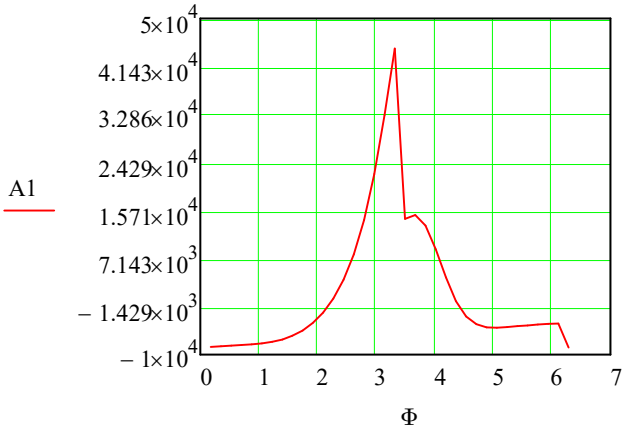
$$-F_{23x}(360deg)\cdot\sin\left(\varphi_2(360deg)\right) + F_{23y}(360deg)\cdot\cos\left(\varphi_2(360deg)\right) \ldots = (0.257)$$
$$+ 0.5\left(-G_2\cdot\cos\left(\varphi_2(360deg)\right) - \Phi_{2x}(360deg)\cdot\sin\left(\varphi_2(360deg)\right) + \Phi_{2y}(360deg)\cdot\cos\left(\varphi_2(360deg)\right)\right) + M_{\Phi 2}(360deg)$$

$x_{36} := 0.257$

$$F_{23x}(360deg)\cdot\cos\left(\varphi_2(360deg)\right) + F_{23y}(360deg)\cdot\sin\left(\varphi_2(360deg)\right) \ldots = \left(-8.768\times 10^{3}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(360deg)\right)\right) + \Phi_{2x}(360deg)\cdot\cos\left(\varphi_2(360deg)\right) + \Phi_{2y}(360deg)\cdot\sin\left(\varphi_2(360deg)\right)$$

$x_{36a} := -8768$





$$F_{23x}(190deg)\cdot\cos\left(\varphi_2(190deg)\right) + F_{23y}(190deg)\cdot\sin\left(\varphi_2(190deg)\right) \ldots = \left(4.461\times 10^{4}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(190deg)\right)\right) + \Phi_{2x}(190deg)\cdot\cos\left(\varphi_2(190deg)\right) + \Phi_{2v}(190deg)\cdot\sin\left(\varphi_2(190deg)\right)$$

$$F_{23x}(191deg)\cdot\cos\left(\varphi_2(191deg)\right) + F_{23y}(191deg)\cdot\sin\left(\varphi_2(191deg)\right) \ldots = \left(4.574\times 10^{4}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(191deg)\right)\right) + \Phi_{2x}(191deg)\cdot\cos\left(\varphi_2(191deg)\right) + \Phi_{2v}(191deg)\cdot\sin\left(\varphi_2(191deg)\right)$$

$$F_{23x}(192deg)\cdot\cos\left(\varphi_2(192deg)\right) + F_{23y}(192deg)\cdot\sin\left(\varphi_2(192deg)\right) \ldots = \left(4.685\times 10^{4}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(192deg)\right)\right) + \Phi_{2x}(192deg)\cdot\cos\left(\varphi_2(192deg)\right) + \Phi_{2v}(192deg)\cdot\sin\left(\varphi_2(192deg)\right)$$

$$F_{23x}(193deg)\cdot\cos\left(\varphi_2(193deg)\right) + F_{23y}(193deg)\cdot\sin\left(\varphi_2(193deg)\right) \ldots = \left(4.792\times 10^{4}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(193deg)\right)\right) + \Phi_{2x}(193deg)\cdot\cos\left(\varphi_2(193deg)\right) + \Phi_{2v}(193deg)\cdot\sin\left(\varphi_2(193deg)\right)$$

$$F_{23x}(194deg)\cdot\cos\left(\varphi_2(194deg)\right) + F_{23y}(194deg)\cdot\sin\left(\varphi_2(194deg)\right) \ldots = \left(1.304\times 10^{4}\right)$$
$$+\left(-G_2\cdot\sin\left(\varphi_2(194deg)\right)\right) + \Phi_{2x}(194deg)\cdot\cos\left(\varphi_2(194deg)\right) + \Phi_{2y}(194deg)\cdot\sin\left(\varphi_2(194deg)\right)$$

$N_2 := 47920$

$-F_{23x}(190deg)\cdot\sin(\varphi_2(190deg)) + F_{23y}(190deg)\cdot\cos(\varphi_2(190deg)) \ldots = (-3.684)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(190deg)) - \Phi_{2x}(190deg)\cdot\sin(\varphi_2(190deg)) + \Phi_{2v}(190deg)\cdot\cos(\varphi_2(190deg))) + M_{\Phi 2}(190deg)$
$-F_{23x}(191deg)\cdot\sin(\varphi_2(191deg)) + F_{23y}(191deg)\cdot\cos(\varphi_2(191deg)) \ldots = (-3.703)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(191deg)) - \Phi_{2x}(191deg)\cdot\sin(\varphi_2(191deg)) + \Phi_{2v}(191deg)\cdot\cos(\varphi_2(191deg))) + M_{\Phi 2}(191deg)$
$-F_{23x}(192deg)\cdot\sin(\varphi_2(192deg)) + F_{23y}(192deg)\cdot\cos(\varphi_2(192deg)) \ldots = (-3.714)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(192deg)) - \Phi_{2x}(192deg)\cdot\sin(\varphi_2(192deg)) + \Phi_{2v}(192deg)\cdot\cos(\varphi_2(192deg))) + M_{\Phi 2}(192deg)$
$-F_{23x}(193\cdot deg)\cdot\sin(\varphi_2(193deg)) + F_{23y}(193deg)\cdot\cos(\varphi_2(193deg)) \ldots = (-3.719)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(193deg)) - \Phi_{2x}(193deg)\cdot\sin(\varphi_2(193deg)) + \Phi_{2v}(193deg)\cdot\cos(\varphi_2(193deg))) + M_{\Phi 2}(193deg)$

$F_{23x}(193deg) = (4.33 \times 10^4)$ $F_{23y}(193deg) = (2.08 \times 10^4)$

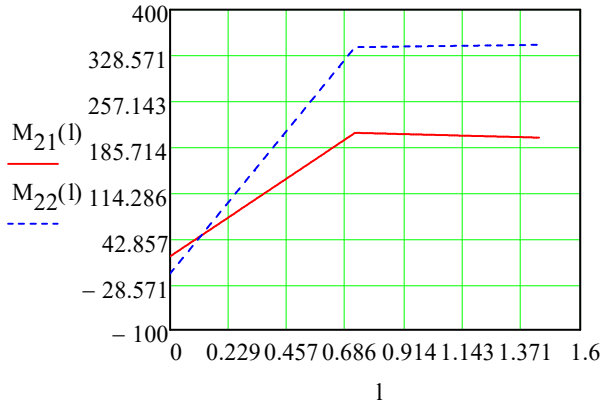
$-F_{23x}(270deg)\cdot\sin(\varphi_2(270deg)) + F_{23y}(270deg)\cdot\cos(\varphi_2(270deg)) \ldots = (4.597)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(270deg)) - \Phi_{2x}(270deg)\cdot\sin(\varphi_2(270deg)) + \Phi_{2v}(270deg)\cdot\cos(\varphi_2(270deg))) + M_{\Phi 2}(270deg)$
$-F_{23x}(271deg)\cdot\sin(\varphi_2(271deg)) + F_{23y}(271deg)\cdot\cos(\varphi_2(271deg)) \ldots = (4.604)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(271deg)) - \Phi_{2x}(271deg)\cdot\sin(\varphi_2(271deg)) + \Phi_{2v}(271deg)\cdot\cos(\varphi_2(271deg))) + M_{\Phi 2}(271deg)$
$-F_{23x}(272deg)\cdot\sin(\varphi_2(272deg)) + F_{23y}(272deg)\cdot\cos(\varphi_2(272deg)) \ldots = (4.607)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(272deg)) - \Phi_{2x}(272deg)\cdot\sin(\varphi_2(272deg)) + \Phi_{2v}(272deg)\cdot\cos(\varphi_2(272deg))) + M_{\Phi 2}(272deg)$
$-F_{23x}(273deg)\cdot\sin(\varphi_2(273deg)) + F_{23y}(273deg)\cdot\cos(\varphi_2(273deg)) \ldots = (4.606)$
$+ 0.5(-G_2\cdot\cos(\varphi_2(273deg)) - \Phi_{2x}(273deg)\cdot\sin(\varphi_2(273deg)) + \Phi_{2y}(273deg)\cdot\cos(\varphi_2(273deg))) + M_{\Phi 2}(273deg)$

$l := 0, 0.01 .. 1.445$

$F_{23x}(272deg) = (-2.765 \times 10^3)$ $F_{23y}(272deg) = (-2.952 \times 10^3)$

$$M_{21}(l) := \begin{cases} 2765\cdot l\cdot\sin(\varphi_2(272deg)) - 2952\cdot l\cdot\cos(\varphi_2(272deg)) \ldots \\ + 0.5\cdot\left(1 - \frac{1.445}{2}\right)\left(-G_2\cdot\cos(\varphi_2(272deg)) - \Phi_{2x}(272deg)\cdot\sin(\varphi_2(272deg)) \ldots \right. \\ \left. + \Phi_{2y}(272deg)\cdot\cos(\varphi_2(272deg))\right) + M_{\Phi 2}(272deg) & \text{if } l > 0.723 \\ 2765\cdot l\cdot\sin(\varphi_2(272deg)) - 2952\cdot l\cdot\cos(\varphi_2(272deg)) + M_{\Phi 2}(272deg) & \text{otherwise} \end{cases}$$

$$M_{22}(l) := \begin{cases} -43300\cdot l\cdot\sin(\varphi_2(193deg)) + 20800\cdot l\cdot\cos(\varphi_2(193deg)) \ldots \\ + 0.5\left(1 - \frac{1.445}{2}\right)\left(-G_2\cdot\cos(\varphi_2(193deg)) - \Phi_{2x}(193deg)\cdot\sin(\varphi_2(193deg)) \ldots \right. \\ \left. + \Phi_{2y}(193deg)\cdot\cos(\varphi_2(193deg))\right) + M_{\Phi 2}(193deg) & \text{if } l > 0.723 \\ -43300\cdot l\cdot\sin(\varphi_2(193deg)) + 20800\cdot l\cdot\cos(\varphi_2(193deg)) + M_{\Phi 2}(193deg) & \text{otherwise} \end{cases}$$



$M_{2max} := |M_{22}(1.445)| = 345.447$

Условие на сжатие:G.t.>N/A

$D_2 := \sqrt{\frac{4N_2}{\pi \cdot G_t}} = 0.015$ м

Условие на изгиб: G.t>M.4max/W.p

$D_2 := \sqrt[3]{\frac{16M_{2max}}{\pi \cdot G_t}} = 0.019$ по Ra40 $D_2 := 0.019$ м

$J_{S2} := \frac{m_2 \cdot \left(l_{AB}^2 + 3\frac{D_2^2}{4} \right)}{12} = 15.662$ кг·м^2

$m_2 := \rho \cdot \pi \frac{D_2^2 \cdot l_{AB}}{4} = 3.216$ кг

Звено 1:

$-F_{12x}(10deg)\cdot\sin(10deg) + F_{12y}(10deg)\cdot\cos(10deg) + M_{Ф1}(10deg) = \left(-4.937 \times 10^3\right)$

$x_1 := -4937$

$-F_{12x}(20deg)\cdot\sin(20deg) + F_{12y}(20deg)\cdot\cos(20deg) + M_{Ф1}(20deg) = \left(-3.587 \times 10^3\right)$

$x_2 := -3587$

$-F_{12x}(30deg)\cdot\sin(30deg) + F_{12y}(30deg)\cdot\cos(30deg) + M_{Ф1}(30deg) = \left(-2.146 \times 10^3\right)$

$x_3 := -2146$

$-F_{12x}(40deg)\cdot\sin(40deg) + F_{12y}(40deg)\cdot\cos(40deg) + M_{Ф1}(40deg) = (-688.729)$

$x_4 := -688.729$

$-F_{12x}(50deg)\cdot\sin(50deg) + F_{12y}(50deg)\cdot\cos(50deg) + M_{Ф1}(50deg) = (699.575)$

$x_5 := 699.575$

$-F_{12x}(60deg)\cdot\sin(60deg) + F_{12y}(60deg)\cdot\cos(60deg) + M_{Ф1}(60deg) = \left(1.93 \times 10^3\right)$

$x_6 := 1930$

$-F_{12x}(70deg)\cdot\sin(70deg) + F_{12y}(70deg)\cdot\cos(70deg) + M_{Ф1}(70deg) = \left(2.916 \times 10^3\right)$

$x_7 := 2916$

$-F_{12x}(80deg)\cdot\sin(80deg) + F_{12y}(80deg)\cdot\cos(80deg) + M_{Ф1}(80deg) = \left(3.574 \times 10^3\right)$

$x_8 := 3574$

$-F_{12x}(90deg)\cdot\sin\left(\varphi_1(90deg)\right) + M_{Ф1}(90deg) = \left(2.49 \times 10^3\right)$

$x_9 := 2490$

$-F_{12x}(100deg)\cdot\sin(100deg) - F_{12y}(100deg)\cdot\cos(100deg) + M_{Ф1}(100deg) = \left(2.775 \times 10^3\right)$

$x_{10} := 2775$

$-F_{12x}(110deg)\cdot\sin(110deg) - F_{12y}(110deg)\cdot\cos(110deg) + M_{Ф1}(110deg) = \left(1.649 \times 10^3\right)$

$x_{11} := 1649$

$-F_{12x}(120deg)\cdot\sin(120deg) - F_{12y}(120deg)\cdot\cos(120deg) + M_{Ф1}(120deg) = (597.945)$

$x_{12} := 597.945$

$-F_{12x}(130deg)\cdot\sin(130deg) - F_{12y}(130deg)\cdot\cos(130deg) + M_{\Phi 1}(130deg) = (-161.476)$

$x_{13} := -161.476$

$-F_{12x}(140deg)\cdot\sin(140deg) - F_{12y}(140deg)\cdot\cos(140deg) + M_{\Phi 1}(140deg) = (-329.685)$

$x_{14} := -329.685$

$-F_{12x}(150deg)\cdot\sin(150deg) - F_{12y}(150deg)\cdot\cos(150deg) + M_{\Phi 1}(150deg) = (512.262)$

$x_{15} := 512.262$

$-F_{12x}(160deg)\cdot\sin(160deg) - F_{12y}(160deg)\cdot\cos(160deg) + M_{\Phi 1}(160deg) = \left(2.952\times 10^{3}\right)$

$x_{16} := 2952$

$-F_{12x}(170deg)\cdot\sin(170deg) - F_{12y}(170deg)\cdot\cos(170deg) + M_{\Phi 1}(170deg) = \left(7.756\times 10^{3}\right)$

$x_{17} := 7756$

$-F_{12y}(180deg)\cdot\cos(180deg) + M_{\Phi 1}(180deg) = \left(1.564\times 10^{4}\right)$

$x_{18} := 15640$

$F_{12x}(190deg)\cdot\sin(190deg) - F_{12y}(190deg)\cdot\cos(190deg) + M_{\Phi 1}(190deg) = \left(1.217\times 10^{4}\right)$

$x_{19} := 12170$

$F_{12x}(200deg)\cdot\sin(200deg) - F_{12y}(200deg)\cdot\cos(200deg) + M_{\Phi 1}(200deg) = (816.403)$

$x_{20} := 816.403$

$F_{12x}(210deg)\cdot\sin(210deg) - F_{12y}(210deg)\cdot\cos(210deg) + M_{\Phi 1}(210deg) = \left(-2.081\times 10^{3}\right)$

$x_{21} := -1008$

$F_{12x}(220deg)\cdot\sin(220deg) - F_{12y}(220deg)\cdot\cos(220deg) + M_{\Phi 1}(220deg) = \left(-4.24\times 10^{3}\right)$

$x_{22} := -2421$

$F_{12x}(230deg)\cdot\sin(230deg) - F_{12y}(230deg)\cdot\cos(230deg) + M_{\Phi 1}(230deg) = \left(-4.393\times 10^{3}\right)$

$x_{23} := -2815$

$F_{12x}(240deg)\cdot\sin(240deg) - F_{12y}(240deg)\cdot\cos(240deg) + M_{\Phi 1}(240deg) = \left(-2.543\times 10^{3}\right)$

$x_{24} := -2059$

$F_{12x}(250deg)\cdot\sin(250deg) - F_{12y}(250deg)\cdot\cos(250deg) + M_{\Phi 1}(250deg) = (173.278)$

$x_{25} := -624.344$

$F_{12x}(260deg)\cdot\sin(260deg) - F_{12y}(260deg)\cdot\cos(260deg) + M_{\Phi 1}(260deg) = \left(2.634\times 10^{3}\right)$

$x_{26} := 2634$

$F_{12x}(270deg)\cdot\sin(270deg) + M_{\Phi 1}(270deg) = \left(4.347\times 10^{3}\right)$

$x_{27} := 2193$

$F_{12x}(280deg)\cdot\sin(280deg) + F_{12y}(280deg)\cdot\cos(280deg) + M_{\Phi 1}(280deg) = \left(3.883\times 10^{3}\right)$

$x_{28} := 1670$

$F_{12x}(290deg)\cdot\sin(290deg) + F_{12y}(290deg)\cdot\cos(290deg) + M_{\Phi 1}(290deg) = \left(2.886 \times 10^{3}\right)$

$x_{29} := 815.924$

$F_{12x}(300deg)\cdot\sin(300deg) + F_{12y}(300deg)\cdot\cos(300deg) + M_{\Phi 1}(300deg) = \left(1.768 \times 10^{3}\right)$

$x_{30} := -73.053$

$F_{12x}(310deg)\cdot\sin(310deg) + F_{12y}(310deg)\cdot\cos(310deg) + M_{\Phi 1}(310deg) = (701.142)$

$x_{31} := -887.895$

$F_{12x}(320deg)\cdot\sin(320deg) + F_{12y}(320deg)\cdot\cos(320deg) + M_{\Phi 1}(320deg) = (-266.124)$

$x_{32} := -1605$

$F_{12x}(330deg)\cdot\sin(330deg) + F_{12y}(330deg)\cdot\cos(330deg) + M_{\Phi 1}(330deg) = \left(-1.13 \times 10^{3}\right)$

$x_{33} := -2228$

$F_{12x}(340deg)\cdot\sin(340deg) + F_{12y}(340deg)\cdot\cos(340deg) + M_{\Phi 1}(340deg) = \left(-1.9 \times 10^{3}\right)$

$x_{34} := -2769$

$F_{12x}(350deg)\cdot\sin(350deg) + F_{12y}(350deg)\cdot\cos(350deg) + M_{\Phi 1}(350deg) = \left(-2.583 \times 10^{3}\right)$

$x_{35} := -3234$

$F_{12x}(360deg)\cdot\sin(360deg) + F_{12y}(360deg)\cdot\cos(360deg) + M_{\Phi 1}(360deg) = \left(-6.137 \times 10^{3}\right)$

$x_{36} := -6137$

$F_{12x}(10deg)\cdot\cos(10deg) + F_{12y}(10deg)\cdot\sin(10deg) = \left(-7.389 \times 10^{3}\right)$

$x_{1a} := -7389$

$F_{12x}(20deg)\cdot\cos(20deg) + F_{12y}(20deg)\cdot\sin(20deg) = \left(-8.062 \times 10^{3}\right)$

$x_{2a} := -8062$

$F_{12x}(30deg)\cdot\cos(30deg) + F_{12y}(30deg)\cdot\sin(30deg) = \left(-8.365 \times 10^{3}\right)$

$x_{31} := -8365$

$F_{12x}(40deg)\cdot\cos(40deg) + F_{12y}(40deg)\cdot\sin(40deg) = \left(-8.276 \times 10^{3}\right)$

$x_{4a} := -8276$

$F_{12x}(50deg)\cdot\cos(50deg) + F_{12y}(50deg)\cdot\sin(50deg) = \left(-7.793 \times 10^{3}\right)$

$x_{5a} := -7793$

$F_{12x}(60deg)\cdot\cos(60deg) + F_{12y}(60deg)\cdot\sin(60deg) = \left(-6.945 \times 10^{3}\right)$

$x_{6a} := -6945$

$F_{12x}(70deg)\cdot\cos(70deg) + F_{12y}(70deg)\cdot\sin(70deg) = \left(-5.787 \times 10^{3}\right)$

$x_{7a} := -5787$

$F_{12x}(80deg)\cdot\cos(80deg) + F_{12y}(80deg)\cdot\sin(80deg) = \left(-4.403 \times 10^{3}\right)$

$x_{8a} := -4403$

$F_{12y}(90deg) \cdot \sin\left(\varphi_1(90deg)\right) = \left(-2.267 \times 10^3\right)$

$x_{9a} := -2267$

$-F_{12x}(100deg) \cdot \cos(100deg) + F_{12y}(100deg) \cdot \sin(100deg) = \left(-3.31 \times 10^3\right)$

$x_{10a} := -3310$

$-F_{12x}(110deg) \cdot \cos(110deg) + F_{12y}(110deg) \cdot \sin(110deg) = \left(-3.123 \times 10^3\right)$

$x_{11a} := -3123$

$-F_{12x}(120deg) \cdot \cos(120deg) + F_{12y}(120deg) \cdot \sin(120deg) = \left(-2.152 \times 10^3\right)$

$x_{12a} := -2152$

$-F_{12x}(130deg) \cdot \cos(130deg) + F_{12y}(130deg) \cdot \sin(130deg) = (-180.252)$

$x_{13a} := -180.252$

$-F_{12x}(140deg) \cdot \cos(140deg) + F_{12y}(140deg) \cdot \sin(140deg) = \left(3.021 \times 10^3\right)$

$x_{14a} := 3021$

$-F_{12x}(150deg) \cdot \cos(150deg) + F_{12y}(150deg) \cdot \sin(150deg) = \left(7.685 \times 10^3\right)$

$x_{15a} := 7685$

$-F_{12x}(160deg) \cdot \cos(160deg) + \left(F_{12y}(160deg)\right) \cdot \sin(160deg) = \left(1.399 \times 10^4\right)$

$x_{16a} := 13990$

$-F_{12x}(170deg) \cdot \cos(170deg) + F_{12y}(170deg) \cdot \sin(170deg) = \left(2.187 \times 10^4\right)$

$x_{17a} := 21870$

$F_{12x}(180deg) \cdot \cos(180deg) = \left(-3.042 \times 10^4\right)$

$x_{18a} := -30420$

$-F_{12x}(190deg) \cdot \cos(190deg) - F_{12y}(190deg) \cdot \sin(190deg) = \left(4.332 \times 10^4\right)$

$x_{19a} := 43320$

$-F_{12x}(200deg) \cdot \cos(200deg) - F_{12y}(200deg) \cdot \sin(200deg) = \left(1.419 \times 10^4\right)$

$x_{20a} := 14190$

$-F_{12x}(210deg) \cdot \cos(210deg) - F_{12y}(210deg) \cdot \sin(210deg) = \left(1.49 \times 10^4\right)$

$x_{21a} := 14900$

$-F_{12x}(220deg) \cdot \cos(220deg) - F_{12y}(220deg) \cdot \sin(220deg) = \left(1.29 \times 10^4\right)$

$x_{22a} := 12900$

$-F_{12x}(230deg) \cdot \cos(230deg) - F_{12y}(230deg) \cdot \sin(230deg) = \left(8.503 \times 10^3\right)$

$x_{23a} := 8503$

$-F_{12x}(240deg) \cdot \cos(240deg) - F_{12y}(240deg) \cdot \sin(240deg) = \left(3.445 \times 10^3\right)$

$x_{24a} := 3445$

$-F_{12x}(250deg)\cdot\cos(250deg) - F_{12y}(250deg)\cdot\sin(250deg) = (-567.661)$

$x_{25a} := -567.661$

$-F_{12x}(260deg)\cdot\cos(260deg) - F_{12y}(260deg)\cdot\sin(260deg) = \left(-2.88 \times 10^{3}\right)$

$x_{26a} := -2880$

$F_{12y}(270deg)\cdot\sin(270deg) = \left(3.718 \times 10^{3}\right)$

$x_{27a} := 3718$

$F_{12x}(280deg)\cdot\cos(280deg) - F_{12y}(280deg)\cdot\sin(280deg) = \left(-4.634 \times 10^{3}\right)$

$x_{28a} := -4634$

$F_{12x}(290deg)\cdot\cos(290deg) - F_{12y}(290deg)\cdot\sin(290deg) = \left(-5.029 \times 10^{3}\right)$

$x_{29a} := -5029$

$F_{12x}(300deg)\cdot\cos(300deg) - F_{12y}(300deg)\cdot\sin(300deg) = \left(-5.079 \times 10^{3}\right)$

$x_{30a} := -5079$

$F_{12x}(310deg)\cdot\cos(310deg) - F_{12y}(310deg)\cdot\sin(310deg) = \left(-4.928 \times 10^{3}\right)$

$x_{31a} := -4928$

$F_{12x}(320deg)\cdot\cos(320deg) - F_{12y}(320deg)\cdot\sin(320deg) = \left(-4.665 \times 10^{3}\right)$

$x_{32a} := -4665$

$F_{12x}(330deg)\cdot\cos(330deg) - F_{12y}(330deg)\cdot\sin(330deg) = \left(-4.334 \times 10^{3}\right)$

$x_{33a} := -4334$

$F_{12x}(340deg)\cdot\cos(340deg) - F_{12y}(340deg)\cdot\sin(340deg) = \left(-3.954 \times 10^{3}\right)$

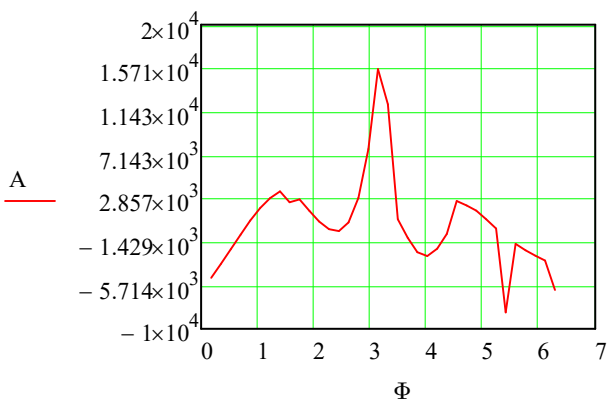
$x_{34a} := -3954$

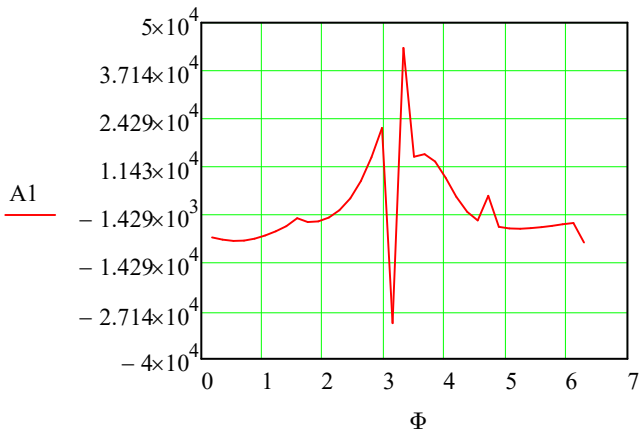
$F_{12x}(350deg)\cdot\cos(350deg) - F_{12y}(350deg)\cdot\sin(350deg) = \left(-3.531 \times 10^{3}\right)$

$x_{35a} := -3531$

$F_{12x}(360deg)\cdot\cos(360deg) = \left(-6.389 \times 10^{3}\right)$

$x_{36a} := -6389$





$F_{12x}(181deg)\cdot\sin(181deg) - F_{12y}(181deg)\cdot\cos(181deg) + M_{Ф1}(181deg) = \left(1.551 \times 10^4\right)$

$-F_{12x}(179deg)\cdot\sin(179deg) - F_{12y}(179deg)\cdot\cos(179deg) + M_{Ф1}(179deg) = \left(1.471 \times 10^4\right)$

$-F_{12x}(191deg)\cdot\cos(191deg) - F_{12y}(191deg)\cdot\sin(191deg) = \left(4.457 \times 10^4\right)$

$-F_{12x}(192deg)\cdot\cos(192deg) - F_{12y}(192deg)\cdot\sin(192deg) = \left(4.578 \times 10^4\right)$

$-F_{12x}(193deg)\cdot\cos(193deg) - F_{12y}(193deg)\cdot\sin(193deg) = \left(4.696 \times 10^4\right)$

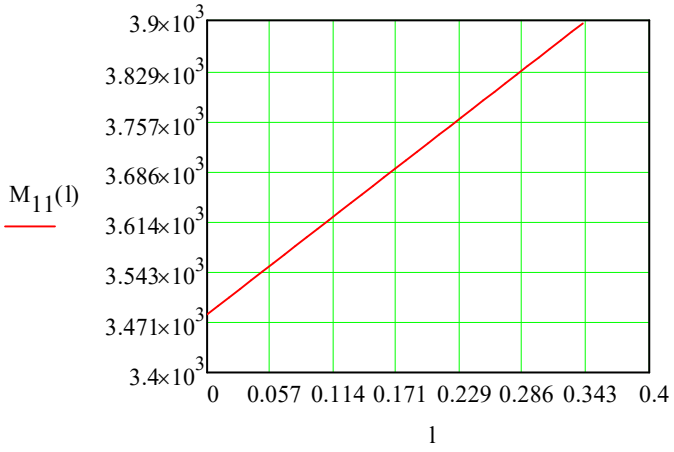
$-F_{12x}(194deg)\cdot\cos(194deg) - F_{12y}(194deg)\cdot\sin(194deg) = \left(1.288 \times 10^4\right)$

$N_1 := 46960$

$l := 0, 0.01 .. 0.347$

$F_{12x}(180deg) = \left(3.042 \times 10^4\right)$ $F_{12y}(180deg) = \left(1.216 \times 10^4\right)$

$M_{11}(l) := 3042\cdot l\cdot\sin(180deg) - 1216\cdot l\cos(180deg) + M_{Ф1}(180deg)$



$M_{1max} := \left|M_{11}(0.347)\right| = 3.905 \times 10^3$

Условие на сжатие:G.t.>N/A

$D_1 := \sqrt{\frac{4N_1}{\pi\cdot G_t}} = 0.015$ м

G.t=M.1max/W.p

$D_1 := \sqrt[3]{\frac{16M_{1max}}{\pi\cdot G_t}} = 0.042$ по Ra40 $D_1 := 0.042$

$J_{S1} := \frac{m_1\cdot\left(l_{OA}^2 + 3\frac{D_1^2}{4}\right)}{12} = 11.196$ кг·м^2

$m_1 := \rho\cdot\pi\frac{D_1^2\cdot l_{OA}}{4} = 3.774$ кг

	Звено 1	Звено 2	Звено 3	Звено 4
m, кг	3,774	3,216	58,956	6,037
J, кг*м^2	11,196	15,662	38,59	52,991
D, м	0,042	0,019	0,075	0,024
l, м	0,347	1,445	1,7	1,7