Appendix

Part A. Velocities and accelerations of the centres of mass of the robot links.

Angular velocity:

$$\boldsymbol{\omega}_1 = \begin{bmatrix} 0 \\ 0 \\ \dot{q}_1 \end{bmatrix}, \tag{A.1}$$

$$\boldsymbol{\omega}_2 = \begin{bmatrix} \dot{q}_1 \, \mathrm{c}_{q_3} \\ -\dot{q}_1 \, \mathrm{s}_{q_3} \\ \dot{q}_2 \end{bmatrix}, \tag{A.2}$$

$$\boldsymbol{\omega}_3 = \begin{bmatrix} \dot{q}_1 \, \mathrm{c}_{q_3} \\ -\dot{q}_1 \, \mathrm{s}_{q_3} \\ \dot{q}_3 \end{bmatrix}, \tag{A.3}$$

$$\boldsymbol{\omega}_4 = \begin{bmatrix} -\dot{q}_3 \, \mathrm{s}_{q_4} + \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \\ -\dot{q}_3 \, \mathrm{c}_{q_4} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \\ \dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3} \end{bmatrix}, \tag{A.4}$$

$$\boldsymbol{\omega}_5 = \begin{bmatrix} \dot{q}_3 \, \mathrm{s}_{q_4} \, \mathrm{c}_{q_5} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} - \mathrm{s}_{q_5} \left(\dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3} \right) \\ -\dot{q}_3 \, \mathrm{s}_{q_4} \, \mathrm{s}_{q_5} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_5} - \mathrm{c}_{q_5} \left(\dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3} \right) \\ \dot{q}_5 + \dot{q}_3 \, \mathrm{c}_{q_4} + \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \end{bmatrix}, \tag{A.5}$$

$$\boldsymbol{\omega}_6 = \begin{bmatrix} \mathrm{s}_{q_6} \left(\dot{q}_5 + \dot{q}_3 \, \mathrm{c}_{q_4} + \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \right) + \mathrm{c}_{q_6} \left(\mathrm{c}_{q_5} \left(\dot{q}_3 \, \mathrm{s}_{q_4} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \right) - \mathrm{s}_{q_5} \left(\dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3} \right) \right) \\ \mathrm{c}_{q_6} \left(\dot{q}_5 + \dot{q}_3 \, \mathrm{c}_{q_4} + \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \right) - \mathrm{s}_{q_6} \left(\mathrm{c}_{q_5} \left(\dot{q}_3 \, \mathrm{s}_{q_4} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \right) - \mathrm{s}_{q_5} \left(\dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3} \right) \right) \\ \dot{q}_6 + \mathrm{c}_{q_5} \left(\dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3} \right) + \mathrm{s}_{q_5} \left(\dot{q}_3 \, \mathrm{s}_{q_4} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \right) \end{bmatrix}. \tag{A.6}$$

Angular acceleration:

$$\boldsymbol{\varepsilon}_1 = \begin{bmatrix} 0 \\ 0 \\ \ddot{q}_1 \end{bmatrix} \tag{A.1}$$

$$\boldsymbol{\varepsilon}_2 = \begin{bmatrix} \ddot{q}_1 \, \mathrm{c}_{q_2} - \dot{q}_1 \, \dot{q}_2 \, \mathrm{s}_{q_2} \\ -\ddot{q}_1 \, \mathrm{s}_{q_2} - \dot{q}_1 \, \dot{q}_2 \, \mathrm{c}_{q_2} \\ \ddot{q}_2 \end{bmatrix} \tag{A.2}$$

$$\boldsymbol{\varepsilon}_3 = \begin{bmatrix} \ddot{q}_1 \, \mathrm{c}_{q_3} - \dot{q}_1 \, \dot{q}_3 \, \mathrm{s}_{q_3} \\ -\ddot{q}_1 \, \mathrm{s}_{q_3} - \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_3} \\ \ddot{q}_3 \end{bmatrix} \tag{A.3}$$

$$\boldsymbol{\varepsilon}_4 = \begin{bmatrix} -\left(\mathrm{s}_{q_1} \, \mathrm{s}_{q_4} + \mathrm{c}_{q_1} \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_3}\right)\sigma_2 - \left(\mathrm{c}_{q_1} \, \mathrm{s}_{q_4} - \mathrm{c}_{q_4} \, \mathrm{s}_{q_1} \, \mathrm{s}_{q_3}\right)\sigma_1 - \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \sigma_3 \\ \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \, \sigma_3 - \left(\mathrm{c}_{q_1} \, \mathrm{c}_{q_4} + \mathrm{s}_{q_1} \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_4}\right)\sigma_1 - \left(\mathrm{c}_{q_4} \, \mathrm{s}_{q_1} - \mathrm{c}_{q_1} \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_4}\right)\sigma_2 \\ \ddot{q}_4 - \ddot{q}_1 \, \mathrm{s}_{q_3} - \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_3} \end{bmatrix} \tag{A.4}$$

where:

$$\begin{aligned} \sigma_1 &= \ddot{q}_3 \, \mathrm{c}_{q_1} - \dot{q}_1 \, \dot{q}_3 \, \mathrm{s}_{q_1} + \ddot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_1} - \dot{q}_3 \dot{q}_4 \, \mathrm{s}_{q_1} \, \mathrm{s}_{q_3} + \dot{q}_1 \dot{q}_4 \, \mathrm{c}_{q_1} \, \mathrm{c}_{q_3} \\ \sigma_2 &= \ddot{q}_3 \, \mathrm{s}_{q_1} + \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_1} - \ddot{q}_4 \, \mathrm{c}_{q_1} \, \mathrm{c}_{q_3} + \dot{q}_1 \, \dot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_1} + \dot{q}_3 \, \dot{q}_4 \, \mathrm{c}_{q_1} \, \mathrm{s}_{q_3} \\ \sigma_3 &= \ddot{q}_4 \, \mathrm{s}_{q_3} - \ddot{q}_1 + \dot{q}_3 \dot{q}_4 \, \mathrm{c}_{q_3} \end{aligned} \tag{A.5}$$

$$\boldsymbol{\varepsilon}_5 = \begin{bmatrix} \ddot{q}_3 \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_4} - \dot{q}_4 \dot{q}_5 \, \mathrm{c}_{q_5} - \ddot{q}_4 \, \mathrm{s}_{q_5} + \ddot{q}_1 \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_5} - \dot{q}_3 \, \dot{q}_5 \, \mathrm{s}_{q_4} \, \mathrm{s}_{q_5} - \ddot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} + \dot{q}_3 \, \dot{q}_4 \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} \\ \dot{q}_4 \, \dot{q}_5 \, \mathrm{s}_{q_5} - \ddot{q}_4 \, \mathrm{c}_{q_5} + \ddot{q}_1 \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_3} - \ddot{q}_3 \, \mathrm{s}_{q_4} \, \mathrm{s}_{q_5} - \dot{q}_1 \dot{q}_5 \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_5} + \ddot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_5} + \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_5} \\ \left(-\dot{q}_1 \, \dot{q}_3\right)\mathrm{s}_{q_3} \, \mathrm{s}_{q_4} + \ddot{q}_1 \, \mathrm{s}_{q_4} \, \mathrm{c}_{q_3} + \left(-\dot{q}_3 \, \dot{q}_4\right)\mathrm{s}_{q_4} \\ + \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_5} + \dot{q}_1 \, \dot{q}_5 \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_3} + \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_3} + \dot{q}_1 \, \dot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_4} + \dot{q}_1 \, \dot{q}_5 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_5} \\ - \dot{q}_3 \, \dot{q}_4 \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_5} - \dot{q}_3 \, \dot{q}_5 \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_4} + \dot{q}_1 \dot{q}_5 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} - \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_5} - \dot{q}_1 \dot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \, \mathrm{s}_{q_5} \\ + \left(\dot{q}_1 \, \dot{q}_4\right)\mathrm{c}_{q_3} \, \mathrm{c}_{q_4} + \ddot{q}_3 \, \mathrm{c}_{q_4} + \ddot{q}_5 \end{bmatrix} \tag{A.6}$$

$$\boldsymbol{\varepsilon}_6 = \begin{bmatrix} \sigma_1 \, \mathrm{s}\left(q_6\right) + \sigma_2 \, \mathrm{c}\left(q_6\right) \\ \mathrm{c}_{q_6} \, \sigma_2 - \mathrm{s}_{q_6} \, \sigma_1 - \dot{q}_6 \left(\mathrm{c}_{q_6} \, \sigma_3 + \mathrm{s}_{q_6} \, \sigma_4\right) \\ \ddot{q}_6 + \sigma_5 \, \mathrm{c}_{q_5} + \sigma_6 \, \mathrm{s}_{q_5} \end{bmatrix} \tag{A.7}$$

where:

$$\begin{aligned} \sigma_1 &= \ddot{q}_3 \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_4} - \dot{q}_4 \dot{q}_5 \, \mathrm{c}_{q_5} - \dot{q}_4 \, \mathrm{s}_{q_5} + \dot{q}_1 \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_5} - \dot{q}_1 \dot{q}_5 \, \mathrm{s}_{q_4} \, \mathrm{s}_{q_5} - \ddot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} + \dot{q}_3 \, \dot{q}_4 \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} \\ &\quad + \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_5} + \dot{q}_1 \, \dot{q}_5 \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_3} + \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_4} \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_3} + \dot{q}_1 \, \dot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_5} \, \mathrm{s}_{q_4} + \dot{q}_1 \dot{q}_5 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_5} \\ \sigma_2 &= \ddot{q}_5 + \ddot{q}_3 \, \mathrm{c}_{q_4} - \dot{q}_3 \, \dot{q}_4 \, \mathrm{s}_{q_4} + \ddot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} - \dot{q}_1 \dot{q}_3 \, \mathrm{s}_{q_3} \, \mathrm{s}_{q_4} + \dot{q}_1 \dot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \\ \sigma_3 &= \mathrm{c}_{q_5} \left(\dot{q}_3 \, \mathrm{s}_{q_4} - \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4}\right) - \mathrm{s}_{q_5} \left(\dot{q}_4 - \dot{q}_1 \, \mathrm{s}_{q_3}\right) \\ \sigma_4 &= \dot{q}_5 + \dot{q}_3 \, \mathrm{c}_{q_4} + \dot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \\ \sigma_5 &= \ddot{q}_4 - \ddot{q}_1 \, \mathrm{s}_{q_3} - \dot{q}_1 \, \dot{q}_3 \, \mathrm{c}_{q_3} + \dot{q}_3 \dot{q}_5 \, \mathrm{s}_{q_4} - \dot{q}_1 \, \dot{q}_5 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} \\ \sigma_6 &= \left(-\dot{q}_4 \, \dot{q}_5\right) + \ddot{q}_3 \, \mathrm{s}_{q_4} + \dot{q}_1 \, \dot{q}_5 \, \mathrm{s}_{q_3} - \ddot{q}_1 \, \mathrm{c}_{q_3} \, \mathrm{c}_{q_4} + \dot{q}_3 \, \dot{q}_4 \, \mathrm{c}_{q_4} + \dot{q}_1 \dot{q}_3 \, \mathrm{c}_{q_4} \, \mathrm{s}_{q_3} + \dot{q}_1 \, \dot{q}_4 \, \mathrm{c}_{q_3} \, \mathrm{s}_{q_4} \end{aligned} \tag{A.8}$$

Linear acceleration:

$$\mathbf{a}_{S1} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \tag{A.9}$$

$$a_{S_2}=\begin{bmatrix}\left(x_{S2}\left(\mathrm{c}_{q2}{}^2-1\right)-a_1\mathrm{s}_{q2}-\mathrm{c}_{q2}\mathrm{s}_{q2}y_{S2}\right)\dot{q}_1{}^2-x_{S2}\dot{q}_2{}^2-y_{S2}\ddot{q}_2\\ \left(-y_{S2}\mathrm{c}_{q2}{}^2-a_1\mathrm{c}_{q2}-\frac{1}{2}x_{S2}\mathrm{s}\left(2q_2\right)\right)\dot{q}_1{}^2-y_{S2}\dot{q}_2{}^2+x_{S2}\ddot{q}_2\\ \left(2\mathrm{c}_{q2}x_{S2}-2\mathrm{s}_{q2}y_{S2}\right)\dot{q}_1\dot{q}_2+\left(a_1+\mathrm{c}_{q2}y_{S2}+\mathrm{s}_{q2}x_{S2}\right)\ddot{q}_1\end{bmatrix} \tag{A.10}$$

$$a_{S_3}=\begin{bmatrix}\left(x_{S3}\left(\sigma_3-\frac{1}{2}\right)-a_1\mathrm{s}_{q_3}-\frac{1}{2}a_2\left(\mathrm{c}_{q_2-q_3}-\mathrm{c}_{q_2+q_3}\right)-\frac{1}{2}y_{S3}\mathrm{s}_{2q_3}\right)\dot{q}_1{}^2-\\ \left(-\frac{1}{2}x_{S3}\mathrm{s}_{2q_3}-a_1\mathrm{c}_{q3}-\frac{1}{2}a_2\left(\mathrm{s}_{q_2-q_3}+\mathrm{s}_{q_2+q_3}\right)-y_{S3}\left(\sigma_3+\frac{1}{2}\right)\right)\dot{q}_1{}^2+\\ \left(2a_2\mathrm{c}_{q_2}\right)\dot{q}_1\dot{q}_2+\left(2\mathrm{c}_{q3}x_{S3}-2\mathrm{s}_{q_3}y_{S3}\right)\dot{q}_1\dot{q}_3+\\ \sigma_2\dot{q}_2{}^2+\sigma_1\ddot{q}_2-x_{S3}\dot{q}_3{}^2-y_{S3}\ddot{q}_3\\ \sigma_1\dot{q}_2{}^2+\sigma_2\ddot{q}_2-y_{S3}\dot{q}_3{}^2+x_{S3}\ddot{q}_3\\ \left(a_1+a_2\mathrm{s}_{q2}+\mathrm{c}_{q3}y_{S3}+\mathrm{s}_{q3}x_{S3}\right)\ddot{q}_1\end{bmatrix} \tag{A.11}$$

where: x

$$\begin{aligned}\sigma_1&=-a_2\sin\left(q_2-q_3\right)\\ \sigma_2&=a_2\cos\left(q_2-q_3\right)\\ \sigma_3&=\tfrac{1}{2}\cos\left(2q_3\right)\end{aligned} \tag{A.12}$$

$$a_{S_4}=\begin{bmatrix}\sigma_1\dot{q}_1{}^2-2a_2\mathrm{c}_{q2}\mathrm{s}_{q4}\dot{q}_1\dot{q}_2+\sigma_2\dot{q}_1\dot{q}_3-a_3\mathrm{c}_{q4}\dot{q}_3{}^2-\sigma_3\ddot{q}_1-\left(\mathrm{c}_{q4}d_4+\mathrm{c}_{q4}z_{S4}\right)\ddot{q}_3-\\ \sigma_4\dot{q}_1{}^2-2a_2\mathrm{c}_{q2}\mathrm{c}_{q4}\dot{q}_1\dot{q}_2+\sigma_5\dot{q}_1\dot{q}_3+a_3\mathrm{s}_{q4}\dot{q}_3{}^2-\sigma_6\ddot{q}_1+\left(d_4\mathrm{s}_{q4}+\mathrm{s}_{q4}z_{S4}\right)\ddot{q}_3+\\ \left(-\frac{1}{2}a_3\mathrm{s}_{2q_3}-a_1\mathrm{c}_{q3}-d_4\mathrm{c}_{q3}{}^2-\mathrm{c}_{q3}{}^2z_{S4}-a_2\mathrm{c}_{q3}\mathrm{s}_{q2}\right)\dot{q}_1{}^2+\\ a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{c}_{q4}+\mathrm{c}_{q4}\mathrm{s}_{q2}\mathrm{s}_{q3}\right)\dot{q}_2{}^2+a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q4}\mathrm{s}_{q3}-\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q2}\right)\ddot{q}_2\\ a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{s}_{q4}+\mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q4}\right)\dot{q}_2{}^2-a_2\left(\mathrm{c}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q4}-\mathrm{c}_{q3}\mathrm{s}_{q2}\mathrm{s}_{q4}\right)\ddot{q}_2\\ a_2\left(\mathrm{c}_{q2}\mathrm{s}_{q3}-\mathrm{c}_{q3}\mathrm{s}_{q2}\right)\dot{q}_2{}^2+a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q3}+\mathrm{s}_{q2}\mathrm{s}_{q3}\right)\ddot{q}_2-\left(d_4+z_{S4}\right)\dot{q}_3{}^2+a_3\ddot{q}_3\end{bmatrix} \tag{A.13}$$

where:

$$\begin{aligned}\sigma_1&=a_3\left(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}-\mathrm{c}_{q4}\right)-a_1\mathrm{c}_{q4}\mathrm{s}_{q3}-a_2\mathrm{c}_{q4}\mathrm{s}_{q2}\mathrm{s}_{q3}-\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q3}z_{S4}-d_4\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q3}\\ \sigma_2&=2d_4\mathrm{s}_{q3}\mathrm{s}_{q4}-2a_3\mathrm{c}_{q3}\mathrm{s}_{q4}+2\mathrm{s}_{q3}\mathrm{s}_{q4}z_{S4}\\ \sigma_3&=a_1\mathrm{s}_{q4}+\mathrm{c}_{q3}d_4\mathrm{s}_{q4}+a_2\mathrm{s}_{q2}\mathrm{s}_{q4}+a_3\mathrm{s}_{q3}\mathrm{s}_{q4}+\mathrm{c}_{q3}\mathrm{s}_{q4}z_{S4}\\ \sigma_4&=a_3\left(s_{\mathrm{q4}}-c_{\mathrm{q3}}{}^2s_{\mathrm{q4}}\right)+a_1s_{\mathrm{q3}}s_{\mathrm{q4}}+d_4c_{\mathrm{q3}}s_{\mathrm{q3}}s_{\mathrm{q4}}+a_2s_{\mathrm{q2}}s_{\mathrm{q3}}s_{\mathrm{q4}}+c_{\mathrm{q3}}s_{\mathrm{q3}}s_{\mathrm{q4}}z_{\mathrm{S4}}\\ \sigma_5&=2d_4c_{\mathrm{q4}}s_{\mathrm{q3}}-2a_3c_{\mathrm{q3}}c_{\mathrm{q4}}+2c_{\mathrm{q4}}s_{\mathrm{q3}}z_{\mathrm{S4}}\\ \sigma_6&=a_1c_{\mathrm{q4}}+c_{\mathrm{q3}}c_{\mathrm{q4}}d_4+a_2c_{\mathrm{q4}}s_{\mathrm{q2}}+a_3c_{\mathrm{q4}}s_{\mathrm{q3}}+c_{\mathrm{q3}}c_{\mathrm{q4}}z_{\mathrm{S4}}\end{aligned} \tag{A.14}$$

$$a_{S_5}=\begin{bmatrix}\sigma_1\dot{q}_1^{\,2}+\left(2a_2\mathrm{c}_{q2}\mathrm{c}_{q5}\mathrm{s}_{q4}\right)\dot{q}_1\dot{q}_2+\left(2a_3\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{s}_{q4}-2\mathrm{c}_{q5}d_4\mathrm{s}_{q3}\mathrm{s}_{q4}\right)\dot{q}_1\dot{q}_3+\sigma_2\ddot{q}_1+\\ \sigma_5\dot{q}_1^{\,2}+\left(-2a_2\mathrm{c}_{q2}\mathrm{s}_{q4}\mathrm{s}_{q5}\right)\dot{q}_1\dot{q}_2+\left(2d_4\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}-2a_3\mathrm{c}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\right)\dot{q}_1\dot{q}_3-\sigma_6\ddot{q}_1-\\ \sigma_9\dot{q}_1^{\,2}+\left(2a_2\mathrm{c}_{q2}\mathrm{c}_{q4}\right)\dot{q}_1\dot{q}_2+\left(2a_3\mathrm{c}_{q3}\mathrm{c}_{q4}-2\mathrm{c}_{q4}d_4\mathrm{s}_{q3}\right)\dot{q}_1\dot{q}_3+\sigma_{10}\ddot{q}_1-\\ \sigma_3\dot{q}_2^{\,2}-\sigma_4\ddot{q}_2+\left(d_4\mathrm{s}_{q5}+a_3\mathrm{c}_{q4}\mathrm{c}_{q5}\right)\dot{q}_3^{\,2}+\left(\mathrm{c}_{q4}\mathrm{c}_{q5}d_4-a_3\mathrm{s}_{q5}\right)\ddot{q}_3\\ \sigma_7\dot{q}_2^{\,2}-\sigma_8\ddot{q}_2+\left(\mathrm{c}_{q5}d_4-a_3\mathrm{c}_{q4}\mathrm{s}_{q5}\right)\dot{q}_3^{\,2}+\left(-a_3\mathrm{c}_{q5}-\mathrm{c}_{q4}d_4\mathrm{s}_{q5}\right)\ddot{q}_3\\ \sigma_{11}\dot{q}_2^{\,2}+\sigma_{12}\ddot{q}_2+\left(-a_3\mathrm{s}_{q4}\right)\dot{q}_3^{\,2}+\left(-d_4\mathrm{s}_{q4}\right)\ddot{q}_3\end{bmatrix} \tag{A.15}$$

where:

$$\begin{aligned}
\sigma_1&=d_4\left(\mathrm{s}_{q5}\mathrm{c}_{q3}^{\,2}+\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{c}_{q3}\right)+a_2\left(\mathrm{c}_{q3}\mathrm{s}_{q2}\mathrm{s}_{q5}+\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q2}\mathrm{s}_{q3}\right)+\\
&\quad a_3\left(-\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q3}^{\,2}+\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{c}_{q3}+\mathrm{c}_{q4}\mathrm{c}_{q5}\right)+a_1\left(\mathrm{c}_{q3}\mathrm{s}_{q5}+\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q3}\right),\\
\sigma_2&=a_1\mathrm{c}_{q5}\mathrm{s}_{q4}+a_2\mathrm{c}_{q5}\mathrm{s}_{q2}\mathrm{s}_{q4}+a_3\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q4}+\mathrm{c}_{q3}\mathrm{c}_{q5}d_4\mathrm{s}_{q4},\\
\sigma_3&=a_2\left(\mathrm{c}_{q3}\mathrm{s}_{q2}\mathrm{s}_{q5}-\mathrm{c}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q5}+\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q2}\mathrm{s}_{q3}+\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\right),\\
\sigma_4&=a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{s}_{q5}+\mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q5}+\mathrm{c}_{q2}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q3}-\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q2}\right),\\
\sigma_5&=d_4\left(\mathrm{c}_{q3}^{\,2}\mathrm{c}_{q5}-\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q3}\mathrm{s}_{q5}\right)+a_2\left(\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{s}_{q2}-\mathrm{c}_{q4}\mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q5}\right)+\\
&\quad a_3\left(\mathrm{c}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q3}^{\,2}+\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{c}_{q3}-\mathrm{c}_{q4}\mathrm{s}_{q5}\right)+a_1\left(\mathrm{c}_{q3}\mathrm{c}_{q5}-\mathrm{c}_{q4}\mathrm{s}_{q3}\mathrm{s}_{q5}\right),\\
\sigma_6&=a_1\mathrm{s}_{q4}\mathrm{s}_{q5}+\mathrm{c}_{q3}d_4\mathrm{s}_{q4}\mathrm{s}_{q5}+a_2\mathrm{s}_{q2}\mathrm{s}_{q4}\mathrm{s}_{q5}+a_3\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5},\\
\sigma_7&=a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q5}\mathrm{s}_{q3}-\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{s}_{q2}+\mathrm{c}_{q4}\mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q5}+\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q5}\right),\\
\sigma_8&=a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{c}_{q5}+\mathrm{c}_{q5}\mathrm{s}_{q2}\mathrm{s}_{q3}-\mathrm{c}_{q2}\mathrm{c}_{q4}\mathrm{s}_{q3}\mathrm{s}_{q5}+\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q2}\mathrm{s}_{q5}\right),\\
\sigma_9&=-a_3\left(\mathrm{s}_{q4}-\mathrm{c}_{q3}^{\,2}\mathrm{s}_{q4}\right)-a_1\mathrm{s}_{q3}\mathrm{s}_{q4}-\mathrm{c}_{q3}d_4\mathrm{s}_{q3}\mathrm{s}_{q4}-a_2\mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q4},\\
\sigma_{10}&=a_1\mathrm{c}_{q4}+\mathrm{c}_{q3}\mathrm{c}_{q4}d_4+a_2\mathrm{c}_{q4}\mathrm{s}_{q2}+a_3\mathrm{c}_{q4}\mathrm{s}_{q3},\\
\sigma_{11}&=a_2\left(\mathrm{c}_{q2}\mathrm{c}_{q3}\mathrm{s}_{q4}+\mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q4}\right),\\
\sigma_{12}&=a_2\left(\mathrm{c}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q4}-\mathrm{c}_{q3}\mathrm{s}_{q2}\mathrm{s}_{q4}\right).
\end{aligned} \tag{A.16}$$

$$\mathbf{a}_{S_6}=\begin{bmatrix}a_{S6x}\\ a_{S6y}\\ a_{S6z}\end{bmatrix} \tag{A.17}$$

where:

$$
\begin{aligned}
a_{S6x} = {} & \Big(a_3\Big(c_{q3}^{\,2}s_{q4}s_{q6} - s_{q4}s_{q6} + c_{q4}c_{q5}c_{q6} + c_{q3}c_{q6}s_{q3}s_{q5} - c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}\Big) - \\
& z_{S6}\Big(-c_{q6}s_{q5}c_{q3}^{\,2}c_{q4}^{\,2}c_{q5} + s_{q4}s_{q5}s_{q6}c_{q3}^{\,2}c_{q4} - c_{q6}s_{q5}c_{q3}^{\,2}c_{q5} - 2c_{q6}s_{q3}c_{q3}c_{q4}c_{q5}^{\,2} + \\
& c_{q6}s_{q3}c_{q3}c_{q4} + s_{q3}s_{q4}s_{q6}c_{q3}c_{q5} + c_{q6}s_{q5}c_{q5}\Big) + a_1\Big(c_{q3}c_{q6}s_{q5} - s_{q3}s_{q4}s_{q6} + \\
& c_{q4}c_{q5}c_{q6}s_{q3}\Big) + d_4\Big(c_{q3}^{\,2}c_{q6}s_{q5} - c_{q3}s_{q3}s_{q4}s_{q6} + c_{q3}c_{q4}c_{q5}c_{q6}s_{q3}\Big) + \\
& a_2\Big(c_{q3}c_{q6}s_{q2}s_{q5} - s_{q2}s_{q3}s_{q4}s_{q6} + \sigma_2\Big)\Big)\dot{q}_1^{\,2} + \Big(a_2\Big(2c_{q2}c_{q4}s_{q6} + 2c_{q2}c_{q5}c_{q6}s_{q4}\Big)\Big)\dot{q}_1\dot{q}_2 + \\
& \Big(a_3\Big(2c_{q3}c_{q4}s_{q6} + 2c_{q3}c_{q5}c_{q6}s_{q4}\Big) - d_4\Big(2c_{q4}s_{q3}s_{q6} + 2c_{q5}c_{q6}s_{q3}s_{q4}\Big) - \\
& z_{S6}\Big(2c_{q4}c_{q5}s_{q3}s_{q6} + 2c_{q3}c_{q4}^{\,2}s_{q5}s_{q6} + 2c_{q5}^{\,2}c_{q6}s_{q3}s_{q4} + 2c_{q3}c_{q4}c_{q5}c_{q6}s_{q4}s_{q5}\Big)\Big)\dot{q}_1\dot{q}_3 + \\
& \Big(z_{S6}\Big(-2c_{q3}c_{q4}c_{q6}c_{q5}^{\,2} + 2c_{q6}s_{q3}s_{q5}c_{q5} + 2c_{q3}c_{q4}c_{q6}\Big)\Big)\dot{q}_1\dot{q}_4 - z_{S6}\Big(2c_{q5}s_{q3}s_{q6} + \\
& 2c_{q3}c_{q4}s_{q5}s_{q6}\Big)\dot{q}_1\dot{q}_5 + \Big(z_{S6}\Big(c_{q3}c_{q6}s_{q4} - s_{q3}s_{q5}s_{q6} + c_{q3}c_{q4}c_{q5}s_{q6}\Big) + d_4\Big(c_{q3}c_{q4}s_{q6} + \\
& c_{q3}c_{q5}c_{q6}s_{q4}\Big) + a_2\Big(c_{q4}s_{q2}s_{q6} + c_{q5}c_{q6}s_{q2}s_{q4}\Big) + a_3\Big(c_{q4}s_{q3}s_{q6} + \\
& c_{q5}c_{q6}s_{q3}s_{q4}\Big) + a_1\sigma_6\Big)\ddot{q}_1 - a_2\Big(c_{q2}c_{q3}s_{q4}s_{q6} + c_{q2}c_{q6}s_{q3}s_{q5} - c_{q3}c_{q6}s_{q2}s_{q5} + \\
& s_{q2}s_{q3}s_{q4}s_{q6} - c_{q2}c_{q3}c_{q4}c_{q5}c_{q6} - \sigma_2\Big)\dot{q}_2^{\,2} - a_2\Big(c_{q3}s_{q2}s_{q4}s_{q6} - c_{q2}s_{q3}s_{q4}s_{q6} + \\
& c_{q6}s_{q2}s_{q3}s_{q5} + c_{q2}c_{q3}c_{q6}s_{q5} + c_{q2}c_{q4}c_{q5}c_{q6}s_{q3} - c_{q3}c_{q4}c_{q5}c_{q6}s_{q2}\Big)\ddot{q}_2 + \\
& \Big(z_{S6}\Big(-c_{q5}c_{q6}s_{q5}c_{q4}^{\,2} + s_{q4}s_{q5}s_{q6}c_{q4} + c_{q5}c_{q6}s_{q5}\Big) - a_3\sigma_3 + c_{q6}d_4s_{q5}\Big)\dot{q}_3^{\,2} - \\
& z_{S6}\Big(2c_{q6}s_{q4} - 2c_{q5}^{\,2}c_{q6}s_{q4}\Big)\dot{q}_3\dot{q}_4 + \Big(2s_{q4}s_{q5}s_{q6}z_{S6}\Big)\dot{q}_3\dot{q}_5 + \\
& \Big(z_{S6}\sigma_4 - d_4\sigma_3 - a_3c_{q6}s_{q5}\Big)\ddot{q}_3 - c_{q5}c_{q6}s_{q5}z_{S6}\dot{q}_4^{\,2} + \\
& 2c_{q5}s_{q6}z_{S6}\dot{q}_4\dot{q}_5 + s_{q5}s_{q6}z_{S6}\ddot{q}_4 + c_{q6}z_{S6}\ddot{q}_5
\end{aligned}
\tag{A.18}
$$

$$
\begin{aligned}
a_{S6y} = &\Big(-a_3\big(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}-c_{q3}{}^2c_{q6}s_{q4}+c_{q3}s_{q3}s_{q5}s_{q6}-c_{q3}{}^2c_{q4}c_{q5}s_{q6}\big)-\\
&-a_1\big(c_{q6}s_{q3}s_{q4}+c_{q3}s_{q5}s_{q6}+c_{q4}c_{q5}s_{q3}s_{q6}\big)-z_{S6}\big(s_{q5}s_{q6}c_{q3}{}^2c_{q4}{}^2c_{q5}+c_{q6}s_{q4}s_{q5}c_{q3}{}^2c_{q4}+\\
&s_{q5}s_{q6}c_{q3}{}^2c_{q5}+2s_{q3}s_{q6}c_{q3}c_{q4}c_{q5}{}^2-s_{q3}s_{q6}c_{q3}c_{q4}+c_{q6}s_{q3}s_{q4}c_{q3}c_{q5}-s_{q5}s_{q6}c_{q5}\big)-\\
&d_4\big(c_{q3}{}^2s_{q5}s_{q6}+c_{q3}c_{q6}s_{q3}s_{q4}+c_{q3}c_{q4}c_{q5}s_{q3}s_{q6}\big)-a_2\big(c_{q6}s_{q2}s_{q3}s_{q4}+c_{q3}s_{q2}s_{q5}s_{q6}+\\
&\sigma_1\big)\big)\dot{q}_1{}^2+\big(a_2\big(2c_{q2}c_{q4}c_{q6}-2c_{q2}c_{q5}s_{q4}s_{q6}\big)\big)\dot{q}_1\dot{q}_2+\big(a_3\big(2c_{q3}c_{q4}c_{q6}-2c_{q3}c_{q5}s_{q4}s_{q6}\big)-\\
&d_4\big(2c_{q4}c_{q6}s_{q3}-2c_{q5}s_{q3}s_{q4}s_{q6}\big)-z_{S6}\big(2c_{q3}c_{q4}{}^2c_{q6}s_{q5}-2c_{q5}{}^2s_{q3}s_{q4}s_{q6}+\\
&2c_{q4}c_{q5}c_{q6}s_{q3}-2c_{q3}c_{q4}c_{q5}s_{q4}s_{q5}s_{q6}\big)\big)\dot{q}_1\dot{q}_3+z_{S6}\big(2c_{q3}c_{q4}s_{q6}c_{q5}{}^2-2s_{q3}s_{q5}s_{q6}c_{q5}-\\
&2c_{q3}c_{q4}s_{q6}\big)\dot{q}_1\dot{q}_4-z_{S6}\big(2c_{q5}c_{q6}s_{q3}+2c_{q3}c_{q4}c_{q6}s_{q5}\big)\dot{q}_1\dot{q}_5+\\
&\big(d_4\big(c_{q3}c_{q4}c_{q6}-c_{q3}c_{q5}s_{q4}s_{q6}\big)z_{S6}\big(c_{q3}s_{q4}s_{q6}+c_{q6}s_{q3}s_{q5}-c_{q3}c_{q4}c_{q5}c_{q6}\big)+\\
&a_2\big(c_{q4}c_{q6}s_{q2}-c_{q5}s_{q2}s_{q4}s_{q6}\big)+a_3\big(c_{q4}c_{q6}s_{q3}-c_{q5}s_{q3}s_{q4}s_{q6}\big)+a_1\sigma_4\big)\ddot{q}_1-\\
&a_2\big(c_{q6}s_{q2}s_{q3}s_{q4}-c_{q2}s_{q3}s_{q5}s_{q6}+c_{q3}s_{q2}s_{q5}s_{q6}+c_{q2}c_{q3}c_{q6}s_{q4}+\\
&c_{q2}c_{q3}c_{q4}c_{q5}s_{q6}+\sigma_1\big)\dot{q}_2{}^2+a_2\big(c_{q2}c_{q6}s_{q3}s_{q4}-c_{q3}c_{q6}s_{q2}s_{q4}+c_{q2}c_{q3}s_{q5}s_{q6}+\\
&s_{q2}s_{q3}s_{q5}s_{q6}+c_{q2}c_{q4}c_{q5}s_{q3}s_{q6}-c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}\big)\ddot{q}_2+\\
&\big(z_{S6}\big(c_{q5}s_{q5}s_{q6}c_{q4}{}^2+c_{q6}s_{q4}s_{q5}c_{q4}-c_{q5}s_{q5}s_{q6}\big)-a_3\sigma_5-d_4s_{q5}s_{q6}\big)\dot{q}_3{}^2+\\
&z_{S6}\big(2s_{q4}s_{q6}-2c_{q5}{}^2s_{q4}s_{q6}\big)\dot{q}_3\dot{q}_4+2c_{q6}s_{q4}s_{q5}z_{S6}\dot{q}_3\dot{q}_5+\big(a_3s_{q5}s_{q6}-d_4\sigma_5-z_{S6}\sigma_6\big)\ddot{q}_3+\\
&c_{q5}s_{q5}s_{q6}z_{S6}\dot{q}_4{}^2+2c_{q5}c_{q6}z_{S6}\dot{q}_4\dot{q}_5+c_{q6}s_{q5}z_{S6}\ddot{q}_4-s_{q6}z_{S6}\ddot{q}_5
\end{aligned}
\tag{A.19}
$$

$$
\begin{aligned}
a_{S6z} = &\Big(-d_4\big(c_{q3}{}^2c_{q5}-c_{q3}c_{q4}s_{q3}s_{q5}\big)-a_2\big(c_{q3}c_{q5}s_{q2}-c_{q4}s_{q2}s_{q3}s_{q5}\big)+z_{S6}\big(-c_{q3}{}^2c_{q4}{}^2c_{q5}{}^2+\\
&c_{q3}{}^2c_{q4}{}^2-c_{q3}{}^2c_{q5}{}^2+2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}+c_{q5}{}^2-1\big)-a_3\big(c_{q4}s_{q5}c_{q3}{}^2+c_{q5}s_{q3}c_{q3}-c_{q4}s_{q5}\big)-\\
&a_1\big(c_{q3}c_{q5}-c_{q4}s_{q3}s_{q5}\big)\big)\dot{q}_1{}^2+\big(2a_2c_{q2}s_{q4}s_{q5}\big)\dot{q}_1\dot{q}_2+\big(-z_{S6}\big(-2c_{q3}c_{q4}s_{q4}c_{q5}{}^2+\\
&2s_{q3}s_{q4}s_{q5}c_{q5}+2c_{q3}c_{q4}s_{q4}\big)+2a_3c_{q3}s_{q4}s_{q5}-2d_4s_{q3}s_{q4}s_{q5}\big)\dot{q}_1\dot{q}_3+\\
&\big(-z_{S6}\big(2s_{q3}c_{q5}{}^2+2c_{q3}c_{q4}s_{q5}c_{q5}-2s_{q3}\big)\big)\dot{q}_1\dot{q}_4+\big(-2c_{q3}s_{q4}z_{S6}\big)\dot{q}_1\dot{q}_5+\\
&\big(a_1s_{q4}s_{q5}+c_{q3}d_4s_{q4}s_{q5}+a_2s_{q2}s_{q4}s_{q5}+a_3s_{q3}s_{q4}s_{q5}\big)\ddot{q}_1+\\
&\big(a_2\big(c_{q2}c_{q5}s_{q3}-c_{q3}c_{q5}s_{q2}+c_{q4}s_{q2}s_{q3}s_{q5}+c_{q2}c_{q3}c_{q4}s_{q5}\big)\big)\dot{q}_2{}^2+\\
&\big(a_2\big(c_{q2}c_{q3}c_{q5}+c_{q5}s_{q2}s_{q3}-c_{q2}c_{q4}s_{q3}s_{q5}+c_{q3}c_{q4}s_{q2}s_{q5}\big)\big)\ddot{q}_2+\\
&\big(-c_{q5}d_4-z_{S6}\big(-c_{q4}{}^2c_{q5}{}^2+c_{q4}{}^2+c_{q5}{}^2\big)+a_3c_{q4}s_{q5}\big)\dot{q}_3{}^2+\\
&\big(2c_{q5}s_{q4}s_{q5}z_{S6}\big)\dot{q}_3\dot{q}_4+\big(-2c_{q4}z_{S6}\big)\dot{q}_3\dot{q}_5+\\
&\big(a_3c_{q5}+c_{q4}d_4s_{q5}\big)\ddot{q}_3+\big(z_{S6}\big(c_{q5}{}^2-1\big)\big)\dot{q}_4{}^2+\big(-z_{S6}\big)\dot{q}_5{}^2
\end{aligned}
\tag{A.20}
$$

$$
\begin{aligned}
\sigma_1 &= \mathrm{c}_{q4}\,\mathrm{c}_{q5}\,\mathrm{s}_{q2}\,\mathrm{s}_{q3}\,\mathrm{s}_{q6}\\
\sigma_2 &= \mathrm{c}_{q4}\,\mathrm{c}_{q5}\,\mathrm{c}_{q6}\,\mathrm{s}_{q2}\,\mathrm{s}_{q3}\\
\sigma_3 &= \mathrm{s}_{q4}\,\mathrm{s}_{q6} - \mathrm{c}_{q4}\,\mathrm{c}_{q5}\,\mathrm{c}_{q6}\\
\sigma_4 &= \mathrm{c}_{q4}\,\mathrm{c}_{q6} - \mathrm{c}_{q5}\,\mathrm{s}_{q4}\,\mathrm{s}_{q6}\\
\sigma_5 &= \mathrm{c}_{q6}\,\mathrm{s}_{q4} + \mathrm{c}_{q4}\,\mathrm{c}_{q5}\,\mathrm{s}_{q6}\\
\sigma_6 &= \mathrm{c}_{q4}\,\mathrm{s}_{q6} + \mathrm{c}_{q5}\,\mathrm{c}_{q6}\,\mathrm{s}_{q4}
\end{aligned}
\tag{A.21}
$$

$$
\mathbf{a}_{ST} = \begin{bmatrix} a_{STx} \\ a_{STy} \\ a_{STz} \end{bmatrix}
\tag{A.22}
$$

where:

$$
\begin{aligned}
a_{STx} = {} & \Big(a_3\big(\mathrm{c}_{q3}{}^2\mathrm{s}_{q4}\mathrm{s}_{q6} - \mathrm{s}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6} + \mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q5} - \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\big) - \big(d_7 + z_{cT}\big)\sigma_2 \\
& + a_1\big(\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q5} - \mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\big) + x_{cT}\big(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 + \\
& \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q6}{}^2 - \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2 - 2\mathrm{s}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6} + \mathrm{c}_{q3}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 - 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}{}^2 + \\
& \mathrm{c}_{q3}{}^2 - 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + 2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q6} - \mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 + \mathrm{c}_{q6}{}^2 - 1\big) - \\
& y_{cT}\sigma_3 + d_4\big(\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}\mathrm{s}_{q5} - \mathrm{c}_{q3}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\big) + a_2\big(\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q2}\mathrm{s}_{q5} - \\
& \mathrm{s}_{q2}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q2}\mathrm{s}_{q3}\big)\big)\dot{q}_1{}^2 + a_2\big(2\mathrm{c}_{q2}\mathrm{c}_{q4}\mathrm{s}_{q6} + 2\mathrm{c}_{q2}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q4}\big)\dot{q}_1\dot{q}_2 + \\
& \Big(y_{cT}\big(-4\mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + 2\mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5} + 2\mathrm{c}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6} + 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{c}_{q4}\mathrm{c}_{q6}{}^2 + \\
& 2\mathrm{c}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q4}\mathrm{c}_{q6} - 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{c}_{q4} + 2\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 - 2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q5}\mathrm{c}_{q6}\big) + \\
& x_{cT}\big(-4\mathrm{c}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6} - 2\mathrm{c}_{q3}\mathrm{s}_{q4}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 - 2\mathrm{c}_{q3}\mathrm{s}_{q4}\mathrm{c}_{q4}\mathrm{c}_{q6}{}^2 + 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q4}\mathrm{c}_{q6} + \\
& 2\mathrm{c}_{q3}\mathrm{s}_{q4}\mathrm{c}_{q4} + 2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + 2\mathrm{c}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q5}\mathrm{c}_{q6}\big) + a_3\big(2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q4}\big) - \\
& d_4\big(2\mathrm{c}_{q4}\mathrm{s}_{q3}\mathrm{s}_{q6} + 2\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4}\big) - \big(d_7 + z_{cT}\big)\sigma_5\big)\dot{q}_1\dot{q}_3 + \Big(\big(d_7 + z_{cT}\big)\big(2c_{q6}s_{q3}s_{q5}c_{q5} - \\
& 2c_{q3}c_{q4}c_{q6}c_{q5}{}^2 + 2c_{q3}c_{q4}c_{q6} + x_{cT}\big(2s_{q3}c_{q5}{}^2c_{q6}{}^2 + 2c_{q3}c_{q4}s_{q5}c_{q5}c_{q6}{}^2 - 2s_{q3}c_{q6}{}^2 - \\
& 2c_{q3}s_{q4}s_{q5}s_{q6}c_{q6} + 2s_{q3}\big) - y_{cT}\big(2s_{q3}s_{q6}c_{q5}{}^2c_{q6} + 2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6} + \\
& 2c_{q3}s_{q4}s_{q5}c_{q6}{}^2 - 2s_{q3}s_{q6}c_{q6}\big)\big)\dot{q}_1\dot{q}_4 + \big(y_{cT}\big(2\mathrm{c}_{q6}{}^2\mathrm{s}_{q3}\mathrm{s}_{q5} - 2\mathrm{s}_{q3}\mathrm{s}_{q5} + 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5} + \\
& 2\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{s}_{q6} - 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2\big) - x_{cT}\big(2\mathrm{c}_{q3}\mathrm{c}_{q6}{}^2\mathrm{s}_{q4} - 2\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q6}\big) \\
& -\big(d_7 + z_{cT}\big)\big(2\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\big)\big)\dot{q}_1\dot{q}_5 + \big(x_{cT}2\mathrm{c}_{q5}\mathrm{s}_{q3} + 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q5}\big)\dot{q}_1\dot{q}_6 + \\
& \big(y_{cT}\big(\mathrm{c}_{q5}\mathrm{s}_{q3} + \mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q5}\big) + \big(d_7 + z_{cT}\big)\big(\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q4} - \mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6} + \mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q6}\big) + \\
& d_4\big(\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q4}\big) + a_2\big(\mathrm{c}_{q4}\mathrm{s}_{q2}\mathrm{s}_{q6} + \mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q2}\mathrm{s}_{q4}\big) + \\
& a_3\big(\mathrm{c}_{q4}\mathrm{s}_{q3}\mathrm{s}_{q6} + \mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4}\big) + a_1\big(\mathrm{c}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q4}\big)\big)\ddot{q}_1 -
\end{aligned}
\tag{A.23}
$$

$$
\begin{aligned}
&a_2\left(c_{q2}c_{q3}s_{q4}s_{q6}+c_{q2}c_{q6}s_{q3}s_{q5}-c_{q3}c_{q6}s_{q2}s_{q5}+\right.\\
&\left.s_{q2}s_{q3}s_{q4}s_{q6}-c_{q2}c_{q3}c_{q4}c_{q5}c_{q6}-c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}\right)\dot{q}_2^{\,2}-\\
&a_2\left(c_{q3}s_{q2}s_{q4}s_{q6}-c_{q2}s_{q3}s_{q4}s_{q6}+c_{q6}s_{q2}s_{q3}s_{q5}+c_{q2}c_{q3}c_{q6}s_{q5}+\right.\\
&\left.c_{q2}c_{q4}c_{q5}c_{q6}s_{q3}-c_{q3}c_{q4}c_{q5}c_{q6}s_{q2}\right)\ddot{q}_2+\\
&\left(\left(d_7+z_{cT}\right)\left(-c_{q5}c_{q6}s_{q5}c_{q4}^{\,2}+s_{q4}s_{q5}s_{q6}c_{q4}+c_{q5}c_{q6}s_{q5}\right)+y_{cT}\sigma_6+\right.\\
&x_{cT}\left(-c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}^{\,2}-c_{q4}^{\,2}c_{q6}^{\,2}+c_{q4}^{\,2}+2s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}+c_{q5}^{\,2}c_{q6}^{\,2}-1\right)-\\
&\left.a_3\left(s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}\right)+d_4c_{q6}s_{q5}\right)\dot{q}_3^{\,2}+\left(-\left(d_7+z_{cT}\right)\left(2c_{q6}s_{q4}-2c_{q5}^{\,2}c_{q6}s_{q4}\right)-\right.\\
&\left.x_{cT}\left(2c_{q5}s_{q4}s_{q5}c_{q6}^{\,2}+2c_{q4}s_{q5}s_{q6}c_{q6}\right)-y_{cT}\left(2c_{q4}c_{q6}^{\,2}s_{q5}-2c_{q5}c_{q6}s_{q4}s_{q5}s_{q6}\right)\right)\dot{q}_3\dot{q}_4+\\
&\left(y_{cT}\left(2c_{q5}s_{q4}c_{q6}^{\,2}+2c_{q4}s_{q6}c_{q6}-2c_{q5}s_{q4}\right)-x_{cT}\left(2c_{q4}c_{q6}^{\,2}-2c_{q5}c_{q6}s_{q4}s_{q6}\right)+\right.\\
&\left.2d_7s_{q4}s_{q5}s_{q6}+2s_{q4}s_{q5}s_{q6}z_{cT}\right)\dot{q}_3\dot{q}_5-\left(2s_{q4}s_{q5}x_{cT}\right)\dot{q}_3\dot{q}_6+z_{cT}\left(c_{q4}c_{q6}-\right.\\
&\left.c_{q5}s_{q4}s_{q6}\right)-d_4\left(s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}\right)+d_7\left(c_{q4}c_{q6}-c_{q5}s_{q4}s_{q6}\right)-a_3c_{q6}s_{q5}-\\
&s_{q4}s_{q5}y_{cT}\ddot{q}_3-\left(x_{cT}\left(c_{q5}^{\,2}c_{q6}^{\,2}-c_{q6}^{\,2}+1\right)+y_{cT}\left(\tfrac{1}{2}s_{2q_6}-c_{q5}^{\,2}c_{q6}s_{q6}\right)+\right.\\
&\left.c_{q5}c_{q6}s_{q5}z_{cT}+c_{q5}c_{q6}d_7s_{q5}\right)\dot{q}_4^{\,2}+\left(y_{cT}\left(2s_{q5}-2c_{q6}^{\,2}s_{q5}\right)+2c_{q5}d_7s_{q6}+\right.\\
&\left.2c_{q5}s_{q6}z_{cT}-2c_{q6}s_{q5}s_{q6}x_{cT}\right)\dot{q}_4\dot{q}_5-2c_{q5}x_{cT}\dot{q}_4\dot{q}_6+\left(d_7s_{q5}s_{q6}-c_{q5}y_{cT}+\right.\\
&\left.s_{q5}s_{q6}z_{cT}\right)\ddot{q}_4+\left(\tfrac{1}{2}y_{cT}s_{2q_6}-c_{q6}^{\,2}x_{cT}\right)\dot{q}_5^{\,2}+\left(c_{q6}d_7+c_{q6}z_{cT}\right)\ddot{q}_5-\\
&x_{cT}\dot{q}_6^{\,2}-y_{cT}\ddot{q}_6
\end{aligned}
$$

$$
\begin{aligned}
a_{STy}=&\left(-y_{cT}\left(c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}^{\,2}-c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}+c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}-2s_{q4}s_{q6}c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}+\right.\right.\\
&c_{q3}^{\,2}c_{q5}^{\,2}c_{q6}^{\,2}-c_{q3}^{\,2}c_{q5}^{\,2}-2c_{q3}^{\,2}c_{q6}^{\,2}+c_{q3}^{\,2}-2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}c_{q6}^{\,2}+2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}+\\
&\left.2s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}c_{q6}-c_{q5}^{\,2}c_{q6}^{\,2}+c_{q5}^{\,2}+c_{q6}^{\,2}\right)-a_3\left(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}-c_{q3}^{\,2}c_{q6}s_{q4}+\right.\\
&\left.c_{q3}s_{q3}s_{q5}s_{q6}-c_{q3}^{\,2}c_{q4}c_{q5}s_{q6}\right)-a_1\left(c_{q6}s_{q3}s_{q4}+c_{q3}s_{q5}s_{q6}+c_{q4}c_{q5}s_{q3}s_{q6}\right)-x_{cT}\sigma_3-\\
&\left(d_7+z_{cT}\right)\sigma_1-d_4\left(c_{q3}^{\,2}s_{q5}s_{q6}+c_{q3}c_{q6}s_{q3}s_{q4}+c_{q3}c_{q4}c_{q5}s_{q3}s_{q6}\right)-a_2\left(c_{q6}s_{q2}s_{q3}s_{q4}+\right.\\
&\left.\left.c_{q3}s_{q2}s_{q5}s_{q6}+c_{q4}c_{q5}s_{q2}s_{q3}s_{q6}\right)\right)\dot{q}_1^{\,2}+a_2\left(2c_{q2}c_{q4}c_{q6}-2c_{q2}c_{q5}s_{q4}s_{q6}\right)\dot{q}_1\dot{q}_2+\\
&\left(y_{cT}\left(4c_{q3}s_{q6}c_{q4}^{\,2}c_{q5}c_{q6}+2c_{q3}s_{q4}c_{q4}c_{q5}^{\,2}c_{q6}^{\,2}-2c_{q3}s_{q4}c_{q4}c_{q5}^{\,2}+2c_{q3}s_{q4}c_{q4}c_{q6}^{\,2}-\right.\right.\\
&\left.2s_{q3}s_{q5}s_{q6}c_{q4}c_{q6}-2s_{q3}s_{q4}s_{q5}c_{q5}c_{q6}^{\,2}-2c_{q3}s_{q6}c_{q5}c_{q6}+2s_{q3}s_{q4}s_{q5}c_{q5}\right)+\\
&a_3\left(2c_{q3}c_{q4}c_{q6}-2c_{q3}c_{q5}s_{q4}s_{q6}\right)-d_4\left(2c_{q4}c_{q6}s_{q3}-2c_{q5}s_{q3}s_{q4}s_{q6}\right)-\left(d_7+z_{cT}\right)\sigma_4\\
&+x_{cT}\left(-4c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}^{\,2}+2c_{q3}c_{q4}^{\,2}c_{q5}+2c_{q3}s_{q4}s_{q6}c_{q4}c_{q5}^{\,2}c_{q6}+2s_{q3}s_{q5}c_{q4}c_{q6}^{\,2}+\right.\\
&\left.\left.2c_{q3}s_{q4}s_{q6}c_{q4}c_{q6}+2c_{q3}c_{q5}c_{q6}^{\,2}-2s_{q3}s_{q4}s_{q5}s_{q6}c_{q5}c_{q6}-2c_{q3}c_{q5}\right)\right)\dot{q}_1\dot{q}_3+
\end{aligned}
\qquad \text{(A.24)}
$$

$$\Big(\big(d_7+z_{cT}\big)\big(2c_{q3}c_{q4}s_{q6}c_{q5}^{\,2}-2s_{q3}s_{q5}s_{q6}c_{q5}-2c_{q3}c_{q4}s_{q6}\big)-x_{cT}\big(2s_{q3}s_{q6}c_{q5}^{\,2}c_{q6}+$$
$$2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6}+2c_{q3}s_{q4}s_{q5}c_{q6}^{\,2}-2s_{q3}s_{q6}c_{q6}-2c_{q3}s_{q4}s_{q5}\big)+$$
$$y_{cT}\big(-2s_{q3}c_{q5}^{\,2}c_{q6}^{\,2}+2s_{q3}c_{q5}^{\,2}-2c_{q3}c_{q4}s_{q5}c_{q5}c_{q6}^{\,2}+2c_{q3}c_{q4}s_{q5}c_{q5}+2s_{q3}c_{q6}^{\,2}+$$
$$2c_{q3}s_{q4}s_{q5}s_{q6}c_{q6}\big)\dot{q}_1\dot{q}_4+\Big(x_{cT}\big(2c_{q6}^{\,2}s_{q3}s_{q5}+2c_{q3}c_{q6}s_{q4}s_{q6}-2c_{q3}c_{q4}c_{q5}c_{q6}^{\,2}\big)-$$
$$\big(d_7-z_{cT}\big)\big(2c_{q5}c_{q6}s_{q3}+2c_{q3}c_{q4}c_{q6}s_{q5}\big)-y_{cT}\big(2c_{q3}s_{q4}-2c_{q3}c_{q6}^{\,2}s_{q4}+$$
$$2c_{q6}s_{q3}s_{q5}s_{q6}-2c_{q3}c_{q4}c_{q5}c_{q6}s_{q6}\big)\Big)\dot{q}_1\dot{q}_5+y_{cT}\big(2c_{q5}s_{q3}+2c_{q3}c_{q4}s_{q5}\big)\dot{q}_1\dot{q}_6+$$
$$\Big(d_4\big(c_{q3}c_{q4}c_{q6}-c_{q3}c_{q5}s_{q4}s_{q6}\big)-\big(d_7-z_{cT}\big)\big(c_{q3}s_{q4}s_{q6}+c_{q6}s_{q3}s_{q5}-c_{q3}c_{q4}c_{q5}c_{q6}\big)-$$
$$x_{cT}\big(c_{q5}s_{q3}+c_{q3}c_{q4}s_{q5}\big)+a_2\big(c_{q4}c_{q6}s_{q2}-c_{q5}s_{q2}s_{q4}s_{q6}\big)+a_3\big(c_{q4}c_{q6}s_{q3}-c_{q5}s_{q3}s_{q4}s_{q6}\big)+$$
$$a_1\big(c_{q4}c_{q6}-c_{q5}s_{q4}s_{q6}\big)\Big)\ddot{q}_1+\Big(-a_2\big(c_{q6}s_{q2}s_{q3}s_{q4}-c_{q2}s_{q3}s_{q5}s_{q6}+c_{q3}s_{q2}s_{q5}s_{q6}+$$
$$c_{q2}c_{q3}c_{q6}s_{q4}+c_{q2}c_{q3}c_{q4}c_{q5}s_{q6}+c_{q4}c_{q5}s_{q2}s_{q3}s_{q6}\big)\Big)\dot{q}_2^{\,2}+\Big(a_2\big(c_{q2}c_{q6}s_{q3}s_{q4}-$$
$$c_{q3}c_{q6}s_{q2}s_{q4}+c_{q2}c_{q3}s_{q5}s_{q6}+s_{q2}s_{q3}s_{q5}s_{q6}+c_{q2}c_{q4}c_{q5}s_{q3}s_{q6}-c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}\big)\Big)\ddot{q}_2+$$
$$\Big(-y_{cT}\big(-c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}^{\,2}+c_{q4}^{\,2}c_{q5}^{\,2}-c_{q4}^{\,2}c_{q6}^{\,2}+2s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}+c_{q5}^{\,2}c_{q6}^{\,2}-c_{q5}^{\,2}+1\big)+$$
$$\big(d_7+z_{cT}\big)\big(c_{q5}s_{q5}s_{q6}c_{q4}^{\,2}+c_{q6}s_{q4}s_{q5}c_{q4}-c_{q5}s_{q5}s_{q6}\big)+x_{cT}\sigma_6-a_3\big(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}\big)-$$
$$d_4s_{q5}s_{q6}\big)\Big)\dot{q}_3^{\,2}+\Big(y_{cT}\big(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}+2c_{q4}s_{q5}s_{q6}c_{q6}-2c_{q5}s_{q4}s_{q5}\big)+$$
$$\big(d_7+z_{cT}\big)\big(2s_{q4}s_{q6}-2c_{q5}^{\,2}s_{q4}s_{q6}\big)+x_{cT}\big(-2c_{q4}s_{q5}c_{q6}^{\,2}+2c_{q5}s_{q4}s_{q5}s_{q6}c_{q6}+2c_{q4}s_{q5}\big)\Big)\dot{q}_3\dot{q}_4+$$
$$\Big(-y_{cT}\big(-2c_{q4}c_{q6}^{\,2}+2c_{q5}s_{q4}s_{q6}c_{q6}+2c_{q4}\big)+x_{cT}\big(2c_{q5}s_{q4}c_{q6}^{\,2}+2c_{q4}s_{q6}c_{q6}\big)+2c_{q6}d_7s_{q4}s_{q5}+$$
$$2c_{q6}s_{q4}s_{q5}z_{cT}\big)\Big)\dot{q}_3\dot{q}_5-2s_{q4}s_{q5}y_{cT}\dot{q}_3\dot{q}_6+\big(a_3s_{q5}s_{q6}-d_4c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}-$$
$$\big(d_7+z_{cT}\big)\big(c_{q4}s_{q6}+c_{q5}c_{q6}s_{q4}\big)+s_{q4}s_{q5}x_{cT}\big)\Big)\ddot{q}_3-\Big(y_{cT}\big(-c_{q5}^{\,2}c_{q6}^{\,2}+c_{q5}^{\,2}+c_{q6}^{\,2}\big)-$$
$$x_{cT}\big(\tfrac{1}{2}s_{2q_6}-c_{q5}^{\,2}c_{q6}s_{q6}+c_{q5}d_7s_{q5}s_{q6}+c_{q5}s_{q5}s_{q6}z_{cT}\big)\Big)\dot{q}_4^{\,2}+\big(2d_7c_{q5}c_{q6}-2c_{q6}^{\,2}s_{q5}x_{cT}+$$
$$2c_{q5}c_{q6}z_{cT}+2c_{q6}s_{q5}s_{q6}y_{cT}\big)\dot{q}_4\dot{q}_5-2c_{q5}y_{cT}\dot{q}_4\dot{q}_6+\big(c_{q5}x_{cT}+c_{q6}d_7s_{q5}+c_{q6}s_{q5}z_{cT}\big)\ddot{q}_4+$$
$$\Big(\tfrac{1}{2}x_{cT}s_{2q_6}+y_{cT}\big(c_{q6}^{\,2}-1\big)\Big)\dot{q}_5^{\,2}-d_7s_{q6}-s_{q6}z_{cT}\ddot{q}_5-y_{cT}\dot{q}_6^{\,2}+x_{cT}\ddot{q}_6$$

$$
\begin{aligned}
a_{STz} = {} & \left(-x_{cT}\sigma_2 - y_{cT}\sigma_1 - d_4\left(c_{q3}^{\,2}c_{q5} - c_{q3}c_{q4}s_{q3}s_{q5}\right) + \left(d_7 + z_{cT}\right)\left(-c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}\right.\right. \\
& + c_{q3}^{\,2}c_{q4}^{\,2} - c_{q3}^{\,2}c_{q5}^{\,2} + 2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5} + c_{q5}^{\,2} - 1\left.\right) - a_2\left(c_{q3}c_{q5}s_{q2} - c_{q4}s_{q2}s_{q3}s_{q5}\right) - \\
& a_3\left(c_{q4}s_{q5}c_{q3}^{\,2} + c_{q5}s_{q3}c_{q3} - c_{q4}s_{q5}\right) - a_1\left(c_{q3}c_{q5} - c_{q4}s_{q3}s_{q5}\right)\left.\right)\dot{q}_1^{\,2} + \\
& \left(2a_2c_{q2}s_{q4}s_{q5}\right)\dot{q}_1\dot{q}_2 + \left(-x_{cT}\left(2c_{q3}s_{q5}s_{q6}c_{q4}^{\,2} + 2c_{q3}c_{q6}s_{q4}s_{q5}c_{q4}c_{q5} + \right.\right. \\
& 2c_{q6}s_{q3}s_{q4}c_{q5}^{\,2} - 2c_{q6}s_{q3}s_{q4} - 2c_{q3}s_{q5}s_{q6}\left.\right) + y_{cT}\left(-2c_{q3}c_{q6}s_{q5}c_{q4}^{\,2} + \right. \\
& 2c_{q3}s_{q4}s_{q5}s_{q6}c_{q4}c_{q5} + 2s_{q3}s_{q4}s_{q6}c_{q5}^{\,2} + 2c_{q3}c_{q6}s_{q5} - 2s_{q3}s_{q4}s_{q6}\left.\right) - \\
& \left(d_7 + z_{cT}\right)\left(-2c_{q3}c_{q4}s_{q4}c_{q5}^{\,2} + 2s_{q3}s_{q4}s_{q5}c_{q5} + 2c_{q3}c_{q4}s_{q4} + 2a_3c_{q3}s_{q4}s_{q5} - \right. \\
& \left.\left.2d_4s_{q3}s_{q4}s_{q5}\right)\right)\dot{q}_1\dot{q}_3 + \left(x_{cT}\left(2c_{q3}c_{q5}s_{q4}s_{q6} + 2c_{q5}c_{q6}s_{q3}s_{q5} - 2c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}\right) - \right. \\
& \left(d_7 + z_{cT}\right)\left(2s_{q3}c_{q5}^{\,2} + 2c_{q3}c_{q4}s_{q5}c_{q5} - 2s_{q3}\right) + \\
& y_{cT}\left(2c_{q3}c_{q4}c_{q5}^{\,2}s_{q6} - 2c_{q5}s_{q3}s_{q5}s_{q6} + 2c_{q3}c_{q5}c_{q6}s_{q4}\right)\dot{q}_1\dot{q}_4 - \left(2c_{q3}d_7s_{q4} + \right. \\
& \left.2c_{q3}s_{q4}z_{cT}\right)\dot{q}_1\dot{q}_5 + \left(x_{cT}\left(2c_{q3}s_{q4}s_{q6} + 2c_{q6}s_{q3}s_{q5} - 2c_{q3}c_{q4}c_{q5}c_{q6}\right) + y_{cT}\left(2c_{q3}c_{q6}s_{q4} - \right.\right. \\
& \left.\left.2s_{q3}s_{q5}s_{q6} + 2c_{q3}c_{q4}c_{q5}s_{q6}\right)\right)\dot{q}_1\dot{q}_6 + \left(y_{cT}\left(c_{q3}s_{q4}s_{q6} + c_{q6}s_{q3}s_{q5} - c_{q3}c_{q4}c_{q5}c_{q6}\right) - \right. \\
& x_{cT}\left(c_{q3}c_{q6}s_{q4} - s_{q3}s_{q5}s_{q6} + c_{q3}c_{q4}c_{q5}s_{q6}\right) + a_1s_{q4}s_{q5} + c_{q3}d_4s_{q4}s_{q5} + a_2s_{q2}s_{q4}s_{q5} + \\
& \left.a_3s_{q3}s_{q4}s_{q5}\right)\ddot{q}_1 + a_2\left(c_{q2}c_{q5}s_{q3} - c_{q3}c_{q5}s_{q2} + c_{q4}s_{q2}s_{q3}s_{q5} + c_{q2}c_{q3}c_{q4}s_{q5}\right)\dot{q}_2^{\,2} + \\
& a_2\left(c_{q2}c_{q3}c_{q5} + c_{q5}s_{q2}s_{q3} - c_{q2}c_{q4}s_{q3}s_{q5} + c_{q3}c_{q4}s_{q2}s_{q5}\right)\ddot{q}_2 + \left(-c_{q5}d_4 + \right. \\
& x_{cT}\left(-c_{q5}c_{q6}s_{q5}c_{q4}^{\,2} + s_{q4}s_{q5}s_{q6}c_{q4} + c_{q5}c_{q6}s_{q5}\right) + y_{cT}\left(c_{q5}s_{q5}s_{q6}c_{q4}^{\,2} + c_{q6}s_{q4}s_{q5}c_{q4} - \right. \\
& \left.c_{q5}s_{q5}s_{q6}\right) - \left(d_7 + z_{cT}\right)\left(-c_{q4}^{\,2}c_{q5}^{\,2} + c_{q4}^{\,2} + c_{q5}^{\,2}\right) + a_3c_{q4}s_{q5}\left.\right)\dot{q}_3^{\,2} + \\
& \left(x_{cT}\left(2c_{q6}s_{q4}c_{q5}^{\,2} + 2c_{q4}s_{q6}c_{q5}\right) - y_{cT}\left(2c_{q5}^{\,2}s_{q4}s_{q6} - 2c_{q4}c_{q5}c_{q6}\right) + 2c_{q5}d_7s_{q4}s_{q5} + \right. \\
& \left.2c_{q5}s_{q4}s_{q5}z_{cT}\right)\dot{q}_3\dot{q}_4 - 2\left(d_7 + z_{cT}\right)c_{q4}\dot{q}_3\dot{q}_5 + x_{cT}\left(2c_{q4}s_{q6} + 2c_{q5}c_{q6}s_{q4}\right) + \\
& y_{cT}\left(\left(2c_{q4}c_{q6} - 2c_{q5}s_{q4}s_{q6}\right)\right)\dot{q}_3\dot{q}_6 + \left(y_{cT}\left(c_{q4}s_{q6} + c_{q5}c_{q6}s_{q4}\right) - x_{cT}\left(c_{q4}c_{q6} - \right.\right. \\
& \left.c_{q5}s_{q4}s_{q6}\right) + a_3c_{q5} + c_{q4}d_4s_{q5}\left.\right)\ddot{q}_3 + \left(d_7 + z_{cT}\right)\left(c_{q5}^{\,2} - 1\right) - c_{q5}c_{q6}s_{q5}x_{cT} + \\
& c_{q5}s_{q5}s_{q6}y_{cT}\left.\right)\dot{q}_4^{\,2} + \left(2s_{q5}s_{q6}y_{cT} - 2c_{q6}s_{q5}x_{cT}\right)\dot{q}_4\dot{q}_6 - \left(c_{q6}s_{q5}y_{cT} + s_{q5}s_{q6}x_{cT}\right)\ddot{q}_4 - \\
& \left(d_7 + z_{cT}\right)\dot{q}_5 + \left(2c_{q6}y_{cT} + 2s_{q6}x_{cT}\right)\dot{q}_5\dot{q}_6 + \left(s_{q6}y_{cT} - c_{q6}x_{cT}\right)\ddot{q}_5
\end{aligned}
\tag{A.25}
$$

$$
\begin{aligned}
\sigma_1 = {} & s_{q5}s_{q6}c_{q3}^{\,2}c_{q4}^{\,2}c_{q5} + c_{q6}s_{q4}s_{q5}c_{q3}^{\,2}c_{q4} + s_{q5}s_{q6}c_{q3}^{\,2}c_{q5} + 2s_{q3}s_{q6}c_{q3}c_{q4}c_{q5}^{\,2} - \\
& s_{q3}s_{q6}c_{q3}c_{q4} + c_{q6}s_{q3}s_{q4}c_{q3}c_{q5} - s_{q5}s_{q6}c_{q5}
\end{aligned}
\tag{A.26}
$$

$$
\begin{aligned}
\sigma_2 = {} & -c_{q6}s_{q5}c_{q3}^{\,2}c_{q4}^{\,2}c_{q5} + s_{q4}s_{q5}s_{q6}c_{q3}^{\,2}c_{q4} - c_{q6}s_{q5}c_{q3}^{\,2}c_{q5} - 2c_{q6}s_{q3}c_{q3}c_{q4}c_{q5}^{\,2} + \\
& c_{q6}s_{q3}c_{q3}c_{q4} + s_{q3}s_{q4}s_{q6}c_{q3}c_{q5} + c_{q6}s_{q5}c_{q5}
\end{aligned}
$$

$$\sigma_3 = s_{q6}c_{q3}^{\ 2}c_{q4}^{\ 2}c_{q5}^{\ 2}c_{q6} + s_{q6}c_{q3}^{\ 2}c_{q4}^{\ 2}c_{q6} + 2s_{q4}c_{q3}^{\ 2}c_{q4}c_{q5}c_{q6}^{\ 2} - s_{q4}c_{q3}^{\ 2}c_{q4}c_{q5} + s_{q6}c_{q3}^{\ 2}c_{q5}^{\ 2}c_{q6} - 2s_{q6}c_{q3}^{\ 2}c_{q6} - 2s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}c_{q5}c_{q6} - 2s_{q3}s_{q4}s_{q5}c_{q3}c_{q6}^{\ 2} + s_{q3}s_{q4}s_{q5}c_{q3} - s_{q6}c_{q5}^{\ 2}c_{q6} + \tfrac{1}{2}s_{2q_6}$$

$$\sigma_4 = 2c_{q3}c_{q4}^{\ 2}c_{q6}s_{q5} - 2c_{q5}^{\ 2}s_{q3}s_{q4}s_{q6} + 2c_{q4}c_{q5}c_{q6}s_{q3} - 2c_{q3}c_{q4}c_{q5}s_{q4}s_{q5}s_{q6}$$

$$\sigma_5 = 2c_{q4}c_{q5}s_{q3}s_{q6} + 2c_{q3}c_{q4}^{\ 2}s_{q5}s_{q6} + 2c_{q5}^{\ 2}c_{q6}s_{q3}s_{q4} + 2c_{q3}c_{q4}c_{q5}c_{q6}s_{q4}s_{q5}$$

$$\sigma_6 = s_{q6}c_{q4}^{\ 2}c_{q5}^{\ 2}c_{q6} + s_{q6}c_{q4}^{\ 2}c_{q6} + 2s_{q4}c_{q4}c_{q5}c_{q6}^{\ 2} - s_{q4}c_{q4}c_{q5} - s_{q6}c_{q5}^{\ 2}c_{q6}$$

Part B. Elementy dynamiki robota

Elements of $\mathbf{M}$ matrix:

$$\mathbf{M} = \begin{bmatrix} M_{11} & \cdots & M_{16} \\ \vdots & \ddots & \vdots \\ M_{61} & \cdots & M_{66} \end{bmatrix} \tag{B.1}$$

$$\begin{aligned} M_{11} = {} & p_4 + p_1 c_{q2}^2 + p_5 \left(2 s_{q4} s_{q6} - 2 c_{q4} c_{q5} c_{q6} + c_{q3}^2 - 2 c_{q3}^2 s_{q4} s_{q6} - 2 c_{q3} c_{q6} s_{q5} - \right. \\ & \left. 2 c_{q3} c_{q6} s_{q3} s_{q5} + 2 c_{q3} s_{q3} s_{q5} s_{q6}\right) + 2 p_6 \left(c_{q4} c_{q5} s_{q6} + 2 c_{q6} s_{q4} - 2 c_{q3}^2 c_{q5} s_{q6} c_{q4} - \right. \\ & \left. 2 c_{q3}^2 c_{q6} s_{q4} + 2 c_{q3} s_{q5} s_{q6}\right) + 2 p_7 \left(c_{q3}^2 c_{q4} s_{q5} + c_{q3} c_{q5} s_{q3} - 2 c_{q4} s_{q5}\right) + \\ & p_{11} \left(c_{q3} c_{q4} s_{q3} s_{q6} + c_{q5} s_{q5} s_{q6} - c_{q3}^2 c_{q4} c_{q6} s_{q4} s_{q5} - 2 c_{q3}^2 c_{q5} s_{q5} s_{q6} - \right. \\ & \left. c_{q5} s_{q5} s_{q6} c_{q4}^2 c_{q3}^2 - 4 c_{q3} c_{q4} s_{q3} s_{q6} c_{q5}^2 - 2 c_{q3} c_{q5} c_{q6} s_{q3} s_{q4}\right) + p_{12} \left(c_{q6}^2 + \right. \\ & \left. c_{q4}^2 c_{q3} c_{q5}^2 c_{q6}^2 - c_{q5}^2 c_{q6}^2 - 2 c_{q3}^2 c_{q6}^2 + c_{q3}^2 c_{q5}^2 c_{q6}^2 + c_{q4}^2 c_{q3}^2 c_{q6}^2 - \right. \\ & \left. 2 c_{q3} c_{q4} c_{q5} c_{q6}^2 s_{q5} s_{q3} + 2 c_{q6} s_{q5} s_{q6} s_{q3} c_{q3} s_{q4} - 2 c_{q3}^2 c_{q5} c_{q6} s_{q4} s_{q6} c_{q4} \right. \\ & \left. - 2 c_{q4} c_{q5} c_{q6} s_{q3}\right) + p_{13} \left(c_{q3}^2 c_{q5}^2 - c_{q5}^2 + c_{q4}^2 c_{q3}^2 c_{q5}^2 - c_{q3} c_{q4} c_{q5} s_{q3} s_{q5}\right) + \\ & p_{14} \left(2 c_{q5}^2 c_{q6} s_{q6} + 4 c_{q4} c_{q6} s_{q6} c_{q3} c_{q5} s_{q3} s_{q5} - s_{2q6} - 2 c_{q4}^2 c_{q3}^2 c_{q5}^2 c_{q6} s_{q6} - \right. \\ & \left. 2 c_{q3}^2 c_{q5}^2 c_{q6} s_{q6} - 4 c_{q3}^2 c_{q6}^2 c_{q5} s_{q4} c_{q4} + 4 c_{q6}^2 s_{q3} s_{q5} c_{q3} s_{q4} + 4 c_{q3}^2 c_{q6} s_{q6}\right) + \\ & 2 p_{15} \left(c_{q3}^2 c_{q4}^2 c_{q5} c_{q6} s_{q5} + c_{q4}^2 c_{q3}^2 c_{q5} c_{q6} s_{q5} c_{q6} s_{q6} + c_{q3}^2 c_{q5} c_{q6} s_{q5} - \right. \\ & \left. c_{q5} c_{q6} s_{q5} - c_{q3} c_{q5} s_{q3} s_{q4} s_{q6} - c_{q3}^2 c_{q4} s_{q4} s_{q5} s_{q6} + c_{q5}^2 c_{q3} c_{q4} c_{q6} s_{q3}\right) + \\ & 2 p_{16} \left(s_{q2} s_{q4} s_{q6} s_{q3} - 2 c_{q3} c_{q6} s_{q2} s_{q5} - 2 c_{q4} c_{q5} c_{q6} s_{q2} s_{q3}\right) + \\ & 2 p_{17} \left(c_{q3} s_{q2} s_{q5} s_{q6} + 2 c_{q4} s_{q2} s_{q6} c_{q5} s_{q3} + 2 c_{q6} s_{q2} s_{q4}\right) + \\ & 2 p_{18} c_{q3} c_{q5} s_{q2} + 2 p_{19} s_{q2} s_{q3} + 2 p_{20} c_{q3} s_{q2} + 2 p_{21} \left(c_{q4} s_{q6} c_{q5} s_{q3} - \right. \\ & \left. c_{q3}^2 c_{q6} s_{q5} + c_{q3} s_{q4} s_{q6} s_{q3} - c_{q4} c_{q6} s_{q2} s_{q5} s_{q3} s_{q5} - c_{q3} c_{q4} c_{q5} c_{q6} s_{q3}\right) \\ & + 2 p_{22} \left(c_{q3} c_{q4} c_{q5} s_{q3} s_{q6} + c_{q3}^2 s_{q5} s_{q6} + c_{q3} c_{q6} s_{q4} s_{q3}\right) + 2 p_{23} s_{q4} s_{q6} s_{q3} + \\ & 2 p_{24} \left(c_{q6} s_{q4} s_{q3} + c_{q2}\right) + 2 p_{25} \left(c_{q3}^2 c_{q5} - c_{q3} c_{q4} s_{q3} s_{q5}\right) + p_{27} s_{2q3} + p_{28} s_{q2} + \\ & p_{29} c_{q3} + p_{30} c_{q3} + p_{31} s_{q3} + 2 p_{32} \left(c_{q3} c_{q5} - c_{q4} s_{q3} s_{q5}\right) - \\ & 2 p_{33} \left(c_{q3}^2 c_{q4} c_{q5} s_{q4} + c_{q3} s_{q3} s_{q4} s_{q5}\right) - p_{34} c_{q3}^2 c_{q4}^2 + \\ & p_{40} \left(s_{2q5} - 2 c_{q3}^2 c_{q5} s_{q5} - 2 c_{q3}^2 c_{q5} s_{q5} c_{q4}^2 - 4 c_{q5}^2 c_{q3} c_{q4} s_{q3}\right) + \\ & 2 p_{41} \left(c_{q5} s_{q3} c_{q3} s_{q4} + 2 c_{q3}^2 s_{q4} s_{q5} c_{q4}\right) - 2 p_{42} c_{q3}^2 c_{q4} s_{q4} \\ & + 2 p_{43} c_{q3} s_{q4} s_{q3} - 2 p_{48} c_{q3} c_{q4} s_{q3} - p_{49} s_{2q2} \end{aligned} \tag{B.2}$$

$$\begin{aligned} M_{12} = M_{21} = {} & p_{45} c_{q_2} - p_{46} s_{q_2} - p_{16} \left(c_{q2} c_{q4} s_{q6} + c_{q_2} c_{q_5} c_{q_6}\right) - \\ & p_{17} \left(c_{q2} c_{q4} c_{q6} + c_{q_2} c_{q_5} s_{q_4} s_{q_6}\right) - p_{18} c_{q_2} s_{q_4} s_{q_5} \end{aligned} \tag{B.3}$$

$$
\begin{aligned}
M_{13} = M_{31} = {} & p_5\left(c_{q5}\,c_{q6}\,s_{q3}\,s_{q4} - c_{q3}\,c_{q5}\,c_{q6}\,s_{q4} - c_{q4}\,c_{q3}\,s_{q6}\right) - p_7\,c_{q3}\,s_{q4}\,s_{q5} + \\
& p_6\left(c_{q3}\,c_{q5}\,s_{q4}\,s_{q6} - c_{q6}\,c_{q4}\,c_{q3}\right) + p_{11}\left(c_{q5}{}^2\,s_{q3}\,s_{q4}\,s_{q6} + c_{q3}\,c_{q6}\,s_{q5} - \right. \\
& 2\,c_{q3}\,c_{q4}{}^2\,c_{q6}\,s_{q5} - s_{q3}\,s_{q4}\,s_{q6} - c_{q4}\,c_{q5}{}^2\,c_{q6}{}^2\,c_{q3}\,s_{q4} + c_{q3}\,c_{q4}\,c_{q5}\,s_{q4}\,s_{q5}\,s_{q6} - \\
& \left. c_{q4}\,c_{q5}\,c_{q6}\,s_{q3}\right) + p_{12}\left(c_{q3}\,c_{q5}\,c_{q6}\,s_{q6} + c_{q4}\,c_{q6}\,s_{q3}\,s_{q5}\,s_{q6} - 2\,c_{q3}\,c_{q4}{}^2\,c_{q5}\,c_{q6}\,s_{q6} - \right. \\
& \left. c_{q3}\,c_{q4}\,c_{q6}{}^2\,s_{q4} + c_{q5}\,c_{q6}{}^2\,s_{q4}\,s_{q3}\,s_{q5}\right) + p_{13}\left(c_{q5}\,s_{q3}\,s_{q4}\,s_{q5} - c_{q3}\,c_{q4}\,c_{q5}{}^2\,s_{q4}\right) + \\
& p_{14}\left(2\,c_{q3}\,c_{q5}\,c_{q6}{}^2 - 4\,c_{q3}\,c_{q4}{}^2\,c_{q5}\,c_{q6}{}^2 + c_{q4}\,c_{q6}\,s_{q3}\,s_{q5} - 2\,c_{q5}\,c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}\,s_{q6} + \right. \\
& \left. c_{q3}\,c_{q4}\,c_{q6}\,s_{q4}\,s_{q6} + 2\,c_{q3}\,c_{q4}\,c_{q6}\,s_{q4}\,s_{q6}\right) + p_{15}\left(c_{q3}\,s_{q5}\,s_{q6} - 2c_{q3}\,s_{q6}\,s_{q5}\,c_{q4}{}^2 - \right. \\
& \left. c_{q5}{}^2\,c_{q6}\,s_{q3}\,s_{q4} - c_{q6}\,s_{q3}\,s_{q4} - c_{q4}\,c_{q5}\,s_{q3}\,s_{q6} - 2\,c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q4}\,s_{q5}\right) + \\
& p_{21}\,c_{q4}\,s_{q3}\,s_{q6} + p_{22}\left(c_{q4}\,c_{q6}\,s_{q3} - c_{q5}\,s_{q3}\,s_{q4}\,s_{q6}\right) + p_{25}\,s_{q3}\,s_{q4}\,s_{q5} + \\
& p_{33}\left(c_{q3}\,c_{q5} + c_{q4}\,s_{q3}\,s_{q5}\right) + p_{34}\,c_{q4}\,c_{q3}\,s_{q4} + 2p_{40}\left(c_{q5}\,s_{q3}\,s_{q4} + 2c_{q5}\,c_{q4}\,c_{q3}\,s_{q4}\,s_{q5}\right) + \\
& p_{41}\left(c_{q4}\,c_{q5}\,s_{q3} - c_{q3}\,s_{q5} + 2\,c_{q3}\,c_{q4}{}^2\,s_{q5}\right) + p_{50}\,c_{q3} - p_{44}\,s_{q3} - 2p_{42}\,c_{q3}\,c_{q4}{}^2 + \\
& p_{43}\,c_{q4}\,s_{q3} + p_{48}\,s_{q4}\,s_{q3} - 2p_{33}\,c_{q3}\,c_{q4}{}^2\,c_{q5}
\end{aligned}
\tag{B.4}
$$

$$
\begin{aligned}
M_{14} = M_{41} = {} & p_5\left(c_{q4}\,c_{q5}\,c_{q6}\,s_{q3} - c_{q6}\,s_{q3}\,s_{q4}\right) - p_6\left(c_{q4}\,c_{q5}\,s_{q3}\,s_{q6} - c_{q6}\,s_{q3}\,s_{q4}\right) + \\
& p_7\,c_{q4}\,s_{q3}\,s_{q5} + p_{11}\left(2\,c_{q3}\,c_{q5}\,c_{q6}\,s_{q4} - c_{q3}\,c_{q4}\,s_{q6} - 2\,c_{q5}\,s_{q3}\,s_{q5}\,s_{q6} + 2\,c_{q5}{}^2\,c_{q3}\,c_{q4}\,s_{q6}\right) + \\
& p_{12}\left(c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}{}^2\,s_{q5} - c_{q6}{}^2\,s_{q3} + c_{q5}{}^2\,c_{q6}{}^2\,s_{q3} - c_{q3}\,c_{q6}\,s_{q4}\,s_{q5}\,s_{q6}\right) \\
& + p_{13}\left(c_{q5}{}^2\,s_{q3} + c_{q3}\,c_{q4}\,c_{q5}\,s_{q5} - c_{q6}{}^2\right) + 2p_{14}\left(2c_{q6}\,s_{q3}\,s_{q6} - 2\,c_{q3}\,c_{q6}{}^2\,s_{q4}\,s_{q5} - \right. \\
& \left. 2\,c_{q5}{}^2\,c_{q6}\,s_{q3}\,s_{q6} - 2c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q5}\,s_{q6}\right) + p_{15}\left(c_{q3}\,c_{q5}\,s_{q4}\,s_{q6} + c_{q4}\,s_{q2}\,s_{q5} + \right. \\
& \left. 2\,c_{q5}\,c_{q6}\,s_{q3}\,s_{q5} - c_{q5}{}^2\,c_{q3}\,c_{q4}\,c_{q6}\right) + p_{16}\left(c_{q4}\,c_{q5}\,c_{q6}\,s_{q2} - s_{q2}\,s_{q4}\,s_{q6}\right) - \\
& p_{17}\left(c_{q6}\,s_{q2}\,s_{q4} + c_{q4}\,c_{q5}\,s_{q2}\,s_{q6}\right) + p_{21}\left(c_{q3}\,c_{q4}\,c_{q5}\,c_{q6} - c_{q3}\,s_{q4}\,s_{q6}\right) - \\
& p_{22}\left(c_{q3}\,c_{q6}\,s_{q4} + c_{q3}\,c_{q4}\,c_{q5}\,s_{q6}\right) + p_{23}\left(c_{q4}\,c_{q5}\,c_{q6} - s_{q4}\,s_{q6}\right) + \\
& p_{24}\left(c_{q4}\,s_{q6} - c_{q4}\,c_{q5}\,s_{q6}\right) + p_{25}\,c_{q3}\,c_{q4}\,s_{q5} + 2p_{32}\,c_{q4}\,s_{q5} - p_{33}\,c_{q3}\,s_{q4}\,s_{q5} + \\
& p_{48}\,c_{q3}\,c_{q4} - p_{35}\,s_{q3} + 2p_{40}\left(c_{q5}{}^2\,c_{q3}\,c_{q4} - 2\,c_{q5}\,s_{q3}\,s_{q5}\right) - \\
& p_{41}\,c_{q5}\,c_{q3}\,s_{q4} - p_{43}\,c_{q3}\,s_{q4}
\end{aligned}
\tag{B.5}
$$

$$
\begin{aligned}
M_{15} = M_{51} = {} & p_6\,s_{q3}\,s_{q4}\,s_{q5}\,s_{q6} - p_5\,s_{q3}\,s_{q4}\,c_{q6}\,s_{q5} + p_7\,c_{q5}\,s_{q3}\,s_{q4} - \\
& p_{11}\left(c_{q3}\,c_{q4}\,c_{q6}\,s_{q5} + 2c_{q5}\,c_{q6}\,s_{q3}\right) + \\
& p_{12}\left(c_{q6}\,s_{q3}\,s_{q5}\,s_{q6} - c_{q3}\,c_{q5}\,c_{q6}\,s_{q6}\,c_{q4} + c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}{}^2\,s_{q5}\right) + \\
& p_{14}\left(c_{q6}{}^2\,s_{q3}\,s_{q5} + 2c_{q3}\,c_{q6}\,s_{q4}\,s_{q6} - 2\,c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}{}^2\right) + \\
& p_{15}\left(c_{q5}\,s_{q2}\,s_{q4} - c_{q3}\,c_{q4}\,s_{q5}\,s_{q6} - c_{q5}\,s_{q3}\,s_{q6}\right) - p_{21}\,c_{q3}\,c_{q6}\,s_{q4}\,s_{q5} - \\
& p_{16}\,s_{q2}\,s_{q4}\,s_{q5}\,c_{q6} + p_{17}\,s_{q2}\,s_{q4}\,s_{q5}\,s_{q6} + \\
& + p_{22}\,c_{q3}\,s_{q4}\,s_{q5}\,s_{q6} - p_{23}\,c_{q6}\,s_{q4}\,s_{q5} + p_{24}\,s_{q4}\,s_{q5}\,s_{q6} + p_{25}\,c_{q3}\,c_{q5}\,s_{q4} + \\
& p_{32}\,c_{q5}\,s_{q4} + p_{33}\,s_{q3}\,s_{q5} - p_{33}\,c_{q3}\,c_{q4}\,c_{q5} + p_{36}\,c_{q3}\,s_{q4} + p_{41}\left(c_{q5}\,s_{q3} + c_{q3}\,c_{q4}\,s_{q5}\right)
\end{aligned}
\tag{B.6}
$$

$$
\begin{aligned}
M_{16} = M_{61} = {} & p_5\left(c_{q4}\,c_{q6}\,s_{q3} - c_{q5}\,s_{q3}\,s_{q4}\,s_{q6}\right) - p_6\left(c_{q4}\,s_{q3}\,s_{q6} + c_{q5}\,c_{q6}\,s_{q3}\,s_{q4}\right) + \\
& + p_{11}\left(c_{q3}\,c_{q4}\,c_{q5}\,s_{q6} - s_{q3}\,s_{q5}\,s_{q6} + c_{q3}\,c_{q6}\,s_{q4}\right) + \\
& p_{15}\left(c_{q3}\,s_{q4}\,s_{q6} + c_{q6}\,s_{q3}\,s_{q5} - c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\right) + \\
& p_{16}\left(c_{q4}\,c_{q6}\,s_{q2} - p_{16}\,c_{q5}\,s_{q2}\,s_{q4}\,s_{q6}\right) - p_{17}\left(c_{q5}\,c_{q6}\,s_{q2}\,s_{q4} + c_{q4}\,s_{q2}\,s_{q6}\right) + \\
& p_{21}\left(c_{q3}\,c_{q4}\,c_{q6} - c_{q3}\,c_{q5}\,s_{q4}\,s_{q6}\right) - p_{22}\left(c_{q3}\,c_{q4}\,s_{q6} + c_{q3}\,c_{q5}\,c_{q6}\,s_{q4}\right) + \\
& p_{23}\left(c_{q4}\,c_{q6} - c_{q5}\,s_{q4}\,s_{q6}\right) - p_{24}\left(c_{q5}\,c_{q6}\,s_{q4} + c_{q4}\,s_{q6}\right) - p_{37}\left(c_{q5}\,s_{q3} + c_{q3}\,c_{q4}\,s_{q5}\right)
\end{aligned}
\tag{B.7}
$$

$$
M_{22} = p_{51} \tag{B.8}
$$

$$M_{23} = M_{32} = p_{16}\left(c_{q2}\,c_{q6}\,s_{q3}\,s_{q5} - c_{q2}\,c_{q3}\,c_{q4}\,c_{q5}\,c_{q6} - c_{q4}\,c_{q5}\,c_{q6}\,s_{q2}\,s_{q3} + c_{q2}\,c_{q3}\,s_{q4}\,s_{q6} + s_{q2}\,s_{q3}\,s_{q4}\,s_{q6} - c_{q3}\,c_{q6}\,s_{q2}\,s_{q5}\right) + p_{17}\left(c_{q3}\,s_{q2}\,s_{q5}\,s_{q6} - c_{q2}\,s_{q3}\,s_{q5}\,s_{q6} + c_{q5}\,s_{q3} + c_{q6}\,s_{q2}\,s_{q3}\,s_{q4} + c_{q2}\,c_{q3}\,c_{q4}\,c_{q5}\,s_{q6} + c_{q2}\,c_{q3}\,c_{q6}\,s_{q4}\right) + p_{18}\left(c_{q3}\,c_{q5}\,s_{q2} - c_{q2}\,c_{q5}\,s_{q3} - c_{q2}\,c_{q4}\,c_{q5}\,s_{q3} - c_{q4}\,s_{q2}\,s_{q3}\,s_{q5}\right) + p_{19}\left(s_{q2}\,s_{q3} + c_{q2}\,c_{q3}\right) + p_{20}\left(c_{q3}\,s_{q2} - c_{q2}\,s_{q3}\right) \tag{B.9}$$

$$M_{24} = M_{42} = p_{17}\left(c_{q5}\,s_{q4}\,s_{q6}\,s_{q_2-q_3} - c_{q4}\,c_{q6}\,s_{q_2-q_3}\right) - p_{16}\left(c_{q4}\,s_{q6}\,s_{q_2-q_3} + c_{q5}\,c_{q6}\,s_{q4}\,s_{q_2-q_3}\right) - p_{38}\,s_{q4}\,s_{q5}\,s_{q_2-q_3} \tag{B.10}$$

$$M_{25} = M_{52} = p_{16}\left(c_{q2}\,c_{q6}\,c_{q4}\,s_{q3}\,s_{q5} - c_{q2}\,c_{q3}\,c_{q5}\,c_{q6} - c_{q4}\,c_{q3}\,c_{q6}\,s_{q2}\,s_{q5} - c_{q5}\,c_{q6}\,s_{q2}\,s_{q3}\right) + p_{17}\left(c_{q2}\,c_{q3}\,c_{q5}\,s_{q6} + c_{q5}\,s_{q2}\,s_{q3}\,s_{q6} - c_{q2}\,c_{q4}\,s_{q3}\,s_{q5}\,s_{q6} + c_{q3}\,c_{q4}\,s_{q2}\,s_{q5}\,s_{q6}\right) + p_{18}\left(c_{q3}\,c_{q4}\,c_{q5}\,s_{q2} - c_{q2}\,c_{q3}\,s_{q5} - c_{q2}\,c_{q4}\,c_{q5}\,s_{q3} - s_{q2}\,s_{q3}\,s_{q5}\right) \tag{B.11}$$

$$M_{26} = M_{62} = p_{16}\left(c_{q2}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q3} + c_{q2}\,c_{q4}\,c_{q5}\,s_{q3}\,s_{q6} + c_{q2}\,c_{q6}\,s_{q3}\,s_{q4} - c_{q3}\,c_{q6}\,s_{q2}\,s_{q4} + c_{q2}\,c_{q3}\,s_{q5}\,s_{q6} + s_{q2}\,s_{q3}\,s_{q5}\,s_{q6} - c_{q3}\,c_{q4}\,c_{q5}\,s_{q2}\,s_{q6}\right) + p_{17}\left(c_{q2}\,c_{q3}\,c_{q6}\,s_{q5} - c_{q2}\,s_{q3}\,s_{q4}\,s_{q6} + c_{q3}\,s_{q2}\,s_{q4}\,s_{q6} + c_{q6}\,s_{q2}\,s_{q3}\,s_{q5} - c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q2}\right) \tag{B.12}$$

$$M_{33} = p_{47} + 2p_5\left(s_{q4}\,s_{q6} - c_{q4}\,c_{q5}\,c_{q6}\right) + 2p_6\left(c_{q4}\,c_{q5}\,s_{q6} + c_{q4}\,c_{q5}\,s_{q6} + c_{q6}\,s_{q4}\right) - 2p_7\,c_{q4}\,s_{q5} + 2p_{11}\left(c_{q4}\,c_{q6}\,s_{q4}\,s_{q5} - c_{q5}\,s_{q5}\,s_{q6} + {c_{q4}}^2\,c_{q5}\,s_{q5}\,s_{q6}\right) + p_{12}\left(2c_{q4}\,c_{q5}\,c_{q6}\,s_{q4}\,s_{q6} - {c_{q4}}^2\,{c_{q5}}^2\,{c_{q6}}^2 + {c_{q5}}^2\,{c_{q6}}^2 - {c_{q4}}^2\,{c_{q6}}^2 + {c_{q4}}^2\right) + p_{13}\left({c_{q5}}^2 - {c_{q4}}^2\,{c_{q5}}^2\right) + p_{14}\left({c_{q4}}^2\,{c_{q5}}^2\,c_{q6}\,s_{q6} + {c_{q4}}^2\,c_{q6}\,s_{q6} - 2{c_{q5}}^2\,c_{q6}\,s_{q6} + 2c_{q4}\,c_{q5}\,{c_{q6}}^2\,s_{q4}\right) + 2p_{15}\left(c_{q4}\,s_{q4}\,s_{q5}\,s_{q6} + c_{q5}\,c_{q6}\,s_{q5} + {c_{q4}}^2\,c_{q5}\,c_{q6}\,s_{q5}\right) - 2p_{21}\,c_{q6}\,s_{q5} + 2p_{22}\,s_{q5}\,s_{q6} + 2p_{25}\,c_{q5} + 2p_{33}\,c_{q4}\,c_{q5}\,s_{q4} + 2p_{40}\left({c_{q4}}^2\,c_{q5}\,s_{q5} - s_{2q_5}\right) - 2p_{41}\,c_{q4}\,s_{q4}\,s_{q5} + p_{42}\,s_{2q_4}} \tag{B.13}$$

$$M_{34} = M_{43} = p_{11}\left(s_{q4}\,s_{q6} - 2{c_{q5}}^2\,s_{q4}\,s_{q6} + p_{11}\,c_{q4}\,c_{q5}\,c_{q6}\right) - p_{12}\left(c_{q4}\,c_{q6}\,s_{q5}\,s_{q6} - c_{q5}\,{c_{q6}}^2\,s_{q4}\,s_{q5}\right) - p_{13}\,c_{q5}\,s_{q4}\,s_{q5} + p_{14}\left(c_{q5}\,c_{q6}\,s_{q4}\,s_{q5}\,s_{q6} - c_{q4}\,{c_{q6}}^2\,s_{q5}\right) + p_{15}\left(c_{q4}\,c_{q5}\,s_{q6} - c_{q6}\,s_{q4} + {c_{q5}}^2\,c_{q6}\,s_{q4}\right) - p_{21}\left(c_{q4}\,s_{q6} + c_{q5}\,c_{q6}\,s_{q4}\right) + p_{22}\left(c_{q5}\,s_{q4}\,s_{q6} - c_{q4}\,c_{q6}\right) - p_{25}\,s_{q4}\,s_{q5} - p_{33}\,c_{q4}\,s_{q5} - 2p_{40}\,{c_{q5}}^2\,s_{q4} - p_{41}\,c_{q4}\,c_{q5} - p_{43}\,c_{q4} - p_{48}\,s_{q4} \tag{B.14}$$

$$M_{35} = M_{53} = \left(-p_5\right)c_{q5}\,c_{q6} + p_6\,c_{q5}\,s_{q6} - p_7\,s_{q5} + p_{11}\,c_{q6}\,s_{q4}\,s_{q5} + p_{12}\left(c_{q5}\,c_{q6}\,s_{q4}\,s_{q6} - c_{q4}\,{c_{q5}}^2\right) + p_{14}\left({c_{q6}}^2\,c_{q5}\,s_{q4} + c_{q4}\,c_{q6}\,s_{q6}\right) + p_{15}\,s_{q4}\,s_{q5}\,s_{q6} - p_{21}\,c_{q4}\,c_{q6}\,s_{q5} + p_{22}\,c_{q4}\,s_{q5}\,s_{q6} + p_{25}\,c_{q4}\,c_{q5} + p_{33}\,c_{q5}\,s_{q4} + p_{36}\,c_{q4} - p_{41}\,s_{q4}\,s_{q5} \tag{B.15}$$

$$M_{36} = M_{63} = p_5\,s_{q5}\,s_{q6} + p_6\,c_{q6}\,s_{q5} + p_{11}\left(c_{q4}\,c_{q6} - c_{q5}\,s_{q4}\,s_{q6}\right) + p_{15}\left(c_{q4}\,s_{q6} + c_{q5}\,c_{q6}\,s_{q4}\right) - p_{21}\left(c_{q6}\,s_{q4} + c_{q4}\,c_{q5}\,s_{q6}\right) + p_{22}\left(c_{q4}\,c_{q5}\,c_{q6} + s_{q4}\,s_{q6}\right) + p_{37}\,s_{q4}\,s_{q5} \tag{B.16}$$

$$M_{44} = p_{35} + 2p_{11}\,c_{q5}\,s_{q5}\,s_{q6} + p_{12}\left({c_{q6}}^2 - {c_{q5}}^2\,{c_{q6}}^2\right) - p_{13}\,{c_{q5}}^2 + p_{14}\left({c_{q5}}^2\,c_{q6}\,s_{q6} - s_{2q_6}\right) + 2p_{15}\,c_{q5}\,c_{q6}\,s_{q5} + p_{40}\,s_{2q_5} \tag{B.17}$$

$$M_{45} = M_{54} = p_{11}\,c_{q5}\,c_{q6} - p_{12}\,c_{q6}\,s_{q5}\,s_{q6} - p_{14}\,{c_{q6}}^2\,s_{q5} + p_{15}\,c_{q5}\,s_{q6} - p_{33}\,s_{q5} - p_{41}\,c_{q5} \tag{B.18}$$

$$M_{46} = M_{64} = p_{11}s_{q5}\,s_{q6} - p_{15}\left(c_{q6}\,s_{q5} + 2{c_{q_3}}^2\,c_{q5}\,c_{q6}\,s_{q5}\right) \tag{B.19}$$

$$M_{55} = p_{36} + p_{14}\,\mathrm{s}_{2q_6} - p_{12}\,\mathrm{c}_{q_6}{}^2 \tag{B.20}$$

$$M_{56} = M_{65} = p_{11}c_{\mathrm{q}6} + p_{15}s_{\mathrm{q}6} \tag{B.21}$$

$$M_{66} = p_{37} \tag{B.22}$$

Parameters:

$$p_1 = \left(I_{2\mathrm{xx}} - I_{2\mathrm{yy}} - m_2\,x_{S2}{}^2 - a_2{}^2\left(m_3 + m_4 + m_5 + m_6 + m_T\right) + m_2\,y_{S2}{}^2\right) \tag{B.23}$$

$$p_2 = a_2{}^2\left(m_3 + m_4 + m_5 + m_6 + m_T\right) \tag{B.24}$$

$$p_3 = 2a_1\,m_2\,y_{S2} \tag{B.25}$$

$$\begin{aligned} p_4 = {} & I_{2yy} + I_{1zz} + I_{3yy} + m_2\,x_{S2}{}^2 + m_3\,x_{S3}{}^2 + p_2 + m_T\,x_{cT}{}^2 + 2d_7\,m_T\,z_{cT} + m_T\,z_{cT}{}^2 \\ & + m_6\,z_{S6}{}^2 + d_7{}^2\,m_T + p_9 + p_{26} + I_{5xx} + I_{4zz} + I_{6yy} + I_{Tyy} - p_{32} \end{aligned} \tag{B.26}$$

$$p_5 = a_3\,m_T\,x_{cT} \tag{B.27}$$

$$p_6 = a_3\,m_T\,y_{cT} \tag{B.28}$$

$$p_7 = a_3 d_7 m_T + a_3 m_6 z_{S6} + a_3 m_T z_{cT} \tag{B.29}$$

$$p_9 = a_3{}^2\left(m_4 + m_5 + m_6 + m_T\right) \tag{B.30}$$

$$p_{10} = I_{5xx} + I_{4zz} + I_{6yy} + I_{Tyy} \tag{B.31}$$

$$p_{11} = I_{6yz} + I_{Tyz} - d_7 m_T y_{cT} - m_T y_{cT} z_{cT} \tag{B.32}$$

$$p_{12} = \left(-m_T\right)x_{cT}{}^2 + m_T\,y_{cT}{}^2 + I_{6xx} - I_{6yy} + I_{Txx} - I_{Tyy} \tag{B.33}$$

$$\begin{aligned} p_{13} = {} & m_T\,d_7{}^2 + 2m_T\,d_7\,z_{cT} - m_T\,y_{cT}{}^2 + m_6\,z_{S6}{}^2 + m_T\,z_{cT}{}^2 + I_{5xx} - I_{5yy} + I_{6yy} - \\ & I_{6zz} + I_{Tyy} - I_{Tzz} \end{aligned} \tag{B.34}$$

$$p_{14} = I_{6xy} + I_{Txy} - m_T x_{cT} y_{cT} \tag{B.35}$$

$$p_{15} = I_{6xz} + I_{Txz} - d_7 m_T x_{cT} - m_T x_{cT} z_{cT} \tag{B.36}$$

$$p_{16} = a_2\,m_T\,x_{\mathrm{c}T} \tag{B.37}$$

$$p_{17} = a_2\,m_T\,y_{cT} \tag{B.38}$$

$$p_{18} = a_2\,d_7\,m_T + a_2\,m_6\,z_{S6} + a_2\,m_T\,z_{cT} \tag{B.39}$$

$$p_{19} = a_2\,a_3\,m_4 + a_2\,a_3\,m_5 + a_2\,a_3\,m_6 + a_2\,a_3\,m_T + a_2\,m_3\,x_{S3} \tag{B.40}$$

$$p_{20} = a_2\,d_4\,m_4 + a_2\,d_4\,m_5 + a_2\,d_4\,m_6 + a_2\,d_4\,m_T + a_2\,m_3\,y_{S3} + a_2\,m_4\,z_{S4} \tag{B.41}$$

$$p_{21} = d_4\,m_T\,x_{\mathrm{c}T} \tag{B.42}$$

$$p_{22} = d_4\,m_T\,y_{\mathrm{c}T} \tag{B.43}$$

$$p_{23} = a_1\,m_T\,x_{cT} \tag{B.44}$$

$$p_{24} = a_1\,m_T\,y_{cT} \tag{B.45}$$

$$p_{25} = d_4\,d_7\,m_T + d_4\,m_6\,z_{S6} + d_4\,m_T\,z_{\mathrm{c}T} \tag{B.46}$$

$$p_{26} = a_1{}^2\left(m_2 + m_3 + m_4 + m_5 + m_6 + m_T\right) \tag{B.47}$$

$$p_{27} = a_3\,d_4\left(m_4 + m_5 + m_6 + m_T\right) + a_3\,m_4\,z_{S4} + m_3\,x_{S3}\,y_{S3} - I_{3\mathrm{xy}} \tag{B.48}$$

$$p_{28} = 2a_1\left(a_2 m_3 + a_2 m_4 + a_2 m_5 + a_2 m_6 + a_2 m_T + m_2 x_{S2}\right) \tag{B.49}$$

$$p_{29} = 2a_1\left(d_4 m_4 + d_4 m_5 + d_4 m_6 + d_4 m_T + m_3 y_{S3} + m_4 z_{S4}\right) \tag{B.50}$$

$$p_{30} = I_{3xx} - I_{3yy} - I_{5xx} + I_{4yy} - I_{4zz} + I_{5zz} + p_{12} - m_3 x_{S3}^2 + m_4 z_{S4}^2 + m_3 y_{S3}^2 + 2d_4 m_4 z_{S4} - a_3^2\left(m_T + m_6 + m_5 + m_4\right) + d_4^2\left(m_T + m_6 + m_5 + m_4\right) \tag{B.51}$$

$$p_{31} = 2a_1\left(a_3 m_4 + a_3 m_5 + a_3 m_6 + a_3 m_T + m_3 x_{S3}\right) \tag{B.52}$$

$$p_{32} = a_1\left(d_7 m_T + m_6 z_{S6} + m_T z_{cT}\right) \tag{B.53}$$

$$p_{33} = I_{5xz} - I_{6xy} - I_{Txy} + m_T x_{cT} y_{cT} \tag{B.54}$$

$$p_{34} = m_T d_7^2 + 2m_T d_7 z_{cT} - m_T x_{cT}^2 + m_6 z_{S6}^2 + m_T z_{cT}^2 - I_{4xx} + I_{4yy} + I_{6xx} - I_{5yy} + I_{5zz} - I_{6zz} + I_{Txx} - I_{Tzz} \tag{B.55}$$

$$p_{35} = \left(I_{5xx} + I_{4zz} + I_{6yy} + I_{Tyy} + m_T z_{cT}^2 + m_6 z_{S6}^2 + d_7^2 m_T + m_T x_{cT}^2 + 2d_7 m_T z_{cT}\right) \tag{B.56}$$

$$p_{36} = m_T d_7^2 + 2m_T d_7 z_{cT} + m_T y_{cT}^2 + m_6 z_{S6}^2 + m_T z_{cT}^2 + I_{6xx} + I_{5zz} + I_{Txx} \tag{B.57}$$

$$p_{37} = m_T x_{cT}^2 + m_T y_{cT}^2 + I_{6zz} + I_{Tzz} \tag{B.58}$$

$$p_{38} = a_2\left(d_7 m_T + m_6 z_{S6} + m_T z_{cT}\right) \tag{B.59}$$

$$p_{39} = d_4^2\left(m_T + m_6 + m_5 + m_4\right) \tag{B.60}$$

$$p_{40} = I_{5xy} \tag{B.61}$$

$$p_{41} = I_{5yz} \tag{B.62}$$

$$p_{42} = I_{4xy} \tag{B.63}$$

$$p_{43} = I_{4yz} \tag{B.64}$$

$$p_{44} = I_{3yz} \tag{B.65}$$

$$p_{45} = I_{2xz} \tag{B.66}$$

$$p_{46} = I_{2yz} \tag{B.67}$$

$$p_{47} = m_T x_{cT}^2 + m_T y_{cT}^2 + I_{6zz} + I_{Tzz} + I_{4xx} + I_{3zz} + I_{5yy} + a_3^2\left(m_4 + m_5 + m_6 + m_T\right) + m_3 x_{S3}^2 + m_4 z_{S4}^2 + m_3 y_{S3}^2 + 2d_4 m_4 z_{S4} + d_4^2\left(m_T + m_6 + m_5 + m_4\right) \tag{B.68}$$

$$p_{48} = I_{4xz} - I_{5xy} \tag{B.69}$$

$$p_{49} = I_{2xy} - m_2 x_{S2} y_{S2} \tag{B.70}$$

$$p_{50} = I_{3xz} + I_{4xy} \tag{B.71}$$

$$p_{51} = a_2^2\left(m_3 + m_4 + m_5 + m_6 + m_T\right) + I_{2zz} + m_2 x_{S2}^2 + m_2 y_{S2}^2 \tag{B.72}$$

Elements of **C** matrix:

$$\mathbf{C}(\mathbf{q},\dot{\mathbf{q}})=\begin{bmatrix} C_{11} & \cdots & C_{16} \\ \vdots & \ddots & \vdots \\ C_{61} & \cdots & C_{66} \end{bmatrix} \tag{B.73}$$

$$\begin{aligned}
C_{11} =& \left(-\tfrac{1}{2}\dot{q}_2 \mathrm{s}_{2q_2}\right)p_1 + \Big(\dot{q}_3\left(\mathrm{c}_{q6}\mathrm{s}_{q5} - \tfrac{1}{2}\mathrm{s}_{2q_3} - \mathrm{s}_{q5}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}{}^2\mathrm{s}_{q5}\mathrm{s}_{q6} + \mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q5} - 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}\mathrm{s}_{q5} + \right.\\
& \left. 2\mathrm{c}_{q3}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\right) + \dot{q}_4\left(-\mathrm{c}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2 + \mathrm{c}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q4}\right) + \dot{q}_5\left(\mathrm{c}_{q4}\mathrm{c}_{q6}\mathrm{s}_{q5} - \mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6} + \right.\\
& \left. \mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q6} - \mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\right) + \dot{q}_6\left(\mathrm{c}_{q6}\mathrm{s}_{q4} + \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q6} + \mathrm{c}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6} - \mathrm{c}_{q3}{}^2\mathrm{c}_{q6}\mathrm{s}_{q4} + \right.\\
& \left. \mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q5} + \mathrm{c}_{q3}\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6}\right)\Big)p_5 + \Big(\dot{q}_4\left(2\mathrm{c}_{q4}\mathrm{c}_{q6} - \mathrm{c}_{q5}\mathrm{s}_{q4}\mathrm{s}_{q6} - 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q6} + \right.\\
& \left. 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}\mathrm{s}_{q4}\mathrm{s}_{q6}\right) + \dot{q}_3\left(4\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4} - 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6} + 4\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q6}\right) + \\
& \dot{q}_5\left(2\mathrm{c}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2 + 2\mathrm{c}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3} - \mathrm{c}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\right) + \dot{q}_6 - 2\mathrm{s}_{q4}\mathrm{s}_{q6} + \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6} + \\
& \left(2\mathrm{c}_{q3}{}^2\mathrm{s}_{q4}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q5} - 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\right)\Big)p_6 + \Big(\dot{q}_3\left(2\mathrm{c}_{q3}{}^2\mathrm{c}_{q5} - \mathrm{c}_{q5} - \right.\\
& \left. 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q3}\mathrm{s}_{q5}\right) + \dot{q}_4\left(2\mathrm{s}_{q4}\mathrm{s}_{q5} - \mathrm{c}_{q3}{}^2\mathrm{s}_{q4}\mathrm{s}_{q5}\right) + \dot{q}_5\left(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5} - \mathrm{c}_{q3}\mathrm{s}_{q3}\mathrm{s}_{q5} - 2\mathrm{c}_{q4}\mathrm{c}_{q5}\right)\Big)p_7 + \\
& \Big(\dot{q}_5\left(-\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2 + \tfrac{1}{2}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2 - \tfrac{1}{2}\mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5} - 2\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}{}^2 + \right.\\
& \left. \mathrm{s}_{q6}\mathrm{c}_{q3}{}^2 + 4\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5} + \mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q3} + \mathrm{s}_{q6}\mathrm{c}_{q5}{}^2 - \tfrac{1}{2}\mathrm{s}_{q6}\right) + \dot{q}_6\left(\tfrac{1}{2}\mathrm{c}_{q6}\mathrm{s}_{q5}\mathrm{c}_{q5} - \right.\\
& \left. \tfrac{1}{2}\mathrm{c}_{q6}\mathrm{s}_{q5}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5} + \tfrac{1}{2}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4} - \mathrm{c}_{q6}\mathrm{s}_{q5}\mathrm{c}_{q3}{}^2\mathrm{c}_{q5} - 2\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2 + \right.\\
& \left. \tfrac{1}{2}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{c}_{q3}\mathrm{c}_{q4} + \mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q5}\right) - \dot{q}_4\left(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q6}\mathrm{s}_{q5} - \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6} - \right.\\
& \left. \tfrac{1}{2}\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}\mathrm{s}_{q5} + \mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3} - 2\mathrm{c}_{q3}\mathrm{c}_{q5}{}^2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6} + \tfrac{1}{2}\mathrm{c}_{q3}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\right) + \dot{q}_3\left(\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4} - \right.\\
& \left. 4\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2 - 2\mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{c}_{q3}{}^2\mathrm{c}_{q5} + \mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5} + \mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q3}\mathrm{c}_{q4} + \right.\\
& \left. 2\mathrm{s}_{q6}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2 + 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q5} - \tfrac{1}{2}\mathrm{s}_{q6}\mathrm{c}_{q4} + \mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{c}_{q5}\right)\Big)p_{11} + \Big(-\dot{q}_6\left(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q6}\mathrm{s}_{q6} - \right.\\
& \left. \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2\mathrm{s}_{q4} - \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q4} + \mathrm{c}_{q3}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}\mathrm{s}_{q6} - 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}\mathrm{s}_{q6} + \right.\\
& \left. \mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}\mathrm{s}_{q6} - 2\mathrm{c}_{q3}\mathrm{c}_{q6}{}^2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5} + \mathrm{c}_{q3}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5} - 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6} - \right.\\
& \left. \mathrm{c}_{q5}{}^2\mathrm{c}_{q6}\mathrm{s}_{q6} + \tfrac{1}{2}\mathrm{s}_{2q_6}\right) - \dot{q}_3\left(\mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6} + \tfrac{1}{2}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2\mathrm{s}_{q3} - 2\mathrm{c}_{q3}\mathrm{c}_{q6}{}^2\mathrm{s}_{q3} - \mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2\mathrm{s}_{q5} + \right.\\
& \left. \mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q6}{}^2\mathrm{s}_{q3} + \mathrm{c}_{q3}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2\mathrm{s}_{q3} + \mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6} + 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2\mathrm{s}_{q5} - \right.\\
& \left. 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6} - 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\right) + \dot{q}_5\left(\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q6} - \right.\\
& \left. \mathrm{s}_{q5}\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 - \mathrm{s}_{q5}\mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 - 2\mathrm{s}_{q3}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 + \mathrm{s}_{q3}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q6}{}^2 + \right.\\
& \left. \mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6} + \mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{c}_{q4}\mathrm{c}_{q6} + \mathrm{s}_{q5}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2\right) + \\
& \dot{q}_4\left(-2\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6} - \mathrm{s}_{q4}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q6}{}^2 + \mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6} - \mathrm{s}_{q4}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 + \right.\\
& \left. \mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q6} + \mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + \mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\right)\Big)p_{12} + \Big(\dot{q}_4\left(\tfrac{1}{2}\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5} - \right.\\
& \left. \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{s}_{q4}\right) - \dot{q}_5\left(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{s}_{q5} + \mathrm{c}_{q3}{}^2\mathrm{c}_{q5}\mathrm{s}_{q5} + \mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{s}_{q3} - \tfrac{1}{2}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{s}_{q3} - \tfrac{1}{2}\mathrm{s}_{2q_5}\right) - \\
& \dot{q}_3\left(\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q5} + \mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2\mathrm{s}_{q3} + \mathrm{c}_{q3}\mathrm{c}_{q5}{}^2\mathrm{s}_{q3} - \tfrac{1}{2}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q5}\right)\Big)p_{13} + \\
& \Big(\dot{q}_4\left(-4\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + 2\mathrm{s}_{q4}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6} + \right.\\
& \left. 2\mathrm{s}_{q3}\mathrm{s}_{q5}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q6}{}^2 - 2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}\right) + \dot{q}_5\left(2\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6} + \right.\\
& \left. 2\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q6}{}^2 + 2\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}\mathrm{c}_{q6} + 4\mathrm{s}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6} - 2\mathrm{s}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q6} + \right.\\
& \left. 2\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{c}_{q3}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 - 2\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q5}\mathrm{c}_{q6}\right) + \dot{q}_3\left(4\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6} + 4\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}{}^2 + \right.\\
& \left. 2\mathrm{s}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6} + 4\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2 + 2\mathrm{s}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q5}{}^2\mathrm{c}_{q6} - 4\mathrm{s}_{q3}\mathrm{s}_{q6}\mathrm{c}_{q3}\mathrm{c}_{q6} - \right.\\
& \left. 2\mathrm{s}_{q5}\mathrm{s}_{q6}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6} - 2\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{c}_{q6}{}^2\right) - \dot{q}_6\left(2\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 - \mathrm{c}_{q3}{}^2\mathrm{c}_{q4}{}^2\mathrm{c}_{q5}{}^2 - \right.\\
& \left. 4\mathrm{c}_{q3}{}^2\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}\mathrm{s}_{q4}\mathrm{s}_{q6} + 2\mathrm{c}_{q3}{}^2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 - \mathrm{c}_{q3}{}^2\mathrm{c}_{q5}{}^2 - 4\mathrm{c}_{q3}{}^2\mathrm{c}_{q6}{}^2 + 2\mathrm{c}_{q3}{}^2 - 2\mathrm{c}_{q5}{}^2\mathrm{c}_{q6}{}^2 + \mathrm{c}_{q5}{}^2 + \right.\\
& \left. 2\mathrm{c}_{q6}{}^2 - 4\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{c}_{q6}{}^2\mathrm{s}_{q3}\mathrm{s}_{q5} + 2\mathrm{c}_{q3}\mathrm{c}_{q4}\mathrm{c}_{q5}\mathrm{s}_{q3}\mathrm{s}_{q5} + 4\mathrm{c}_{q3}\mathrm{c}_{q6}\mathrm{s}_{q3}\mathrm{s}_{q4}\mathrm{s}_{q5}\mathrm{s}_{q6} - 1)\Big)p_{14} +
\end{aligned} \tag{B.74}$$

$$\left(-\dot{q}_6\left(-3c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}c_{q6}^{\,3}s_{q5}+2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}c_{q6}s_{q5}+c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}s_{q5}s_{q6}+c_{q3}^{\,2}c_{q4}c_{q6}s_{q4}s_{q5}+\right.\right.$$
$$c_{q3}^{\,2}c_{q5}s_{q5}s_{q6}+c_{q3}c_{q4}c_{q5}^{\,2}s_{q3}s_{q6}+c_{q3}c_{q5}c_{q6}s_{q3}s_{q4}-c_{q5}s_{q5}s_{q6}\Big)-\dot{q}_3\Big(-2c_{q3}^{\,2}c_{q4}c_{q5}^{\,2}c_{q6}+$$
$$2c_{q3}^{\,2}c_{q5}s_{q4}s_{q6}+2c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}^{\,2}s_{q3}s_{q5}s_{q6}+2c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}s_{q3}s_{q5}-2c_{q3}c_{q4}s_{q3}s_{q4}s_{q5}s_{q6}+$$
$$2c_{q3}c_{q5}c_{q6}s_{q3}s_{q5}+c_{q4}c_{q5}^{\,2}c_{q6}-c_{q5}s_{q4}s_{q6}\Big)-\dot{q}_4\Big(2c_{q3}^{\,2}c_{q4}^{\,2}s_{q5}s_{q6}-c_{q3}^{\,2}s_{q5}s_{q6}+$$
$$2c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}^{\,2}s_{q4}s_{q5}s_{q6}+2c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}s_{q4}s_{q5}+c_{q3}c_{q4}c_{q5}s_{q3}s_{q6}+c_{q3}c_{q5}^{\,2}c_{q6}s_{q3}s_{q4}\Big)-$$
$$\dot{q}_5\Big(-2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}^{\,2}s_{q6}-2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}+c_{q3}^{\,2}c_{q4}^{\,2}c_{q6}^{\,2}s_{q6}+c_{q3}^{\,2}c_{q4}^{\,2}c_{q6}+$$
$$c_{q3}^{\,2}c_{q4}c_{q5}s_{q4}s_{q6}-2c_{q3}^{\,2}c_{q5}^{\,2}c_{q6}+c_{q3}^{\,2}c_{q6}+2c_{q3}c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}-c_{q3}s_{q3}s_{q4}s_{q5}s_{q6}+$$
$$\left.2c_{q5}^{\,2}c_{q6}-c_{q6}\right)\Big)p_{15}+\Big(-\dot{q}_2\left(2c_{q2}c_{q3}c_{q6}s_{q5}-c_{q2}s_{q3}s_{q4}s_{q6}+2c_{q2}c_{q4}c_{q5}c_{q6}s_{q3}\right)+$$
$$\dot{q}_5\left(2c_{q4}c_{q6}s_{q2}s_{q3}s_{q5}-2c_{q3}c_{q5}c_{q6}s_{q2}\right)+\dot{q}_3\left(c_{q3}s_{q2}s_{q4}s_{q6}+2c_{q6}s_{q2}s_{q3}s_{q5}-\right.$$
$$2c_{q3}c_{q4}c_{q5}c_{q6}s_{q2}\Big)+\dot{q}_4\left(c_{q4}s_{q2}s_{q3}s_{q6}+2c_{q5}c_{q6}s_{q2}s_{q3}s_{q4}\right)+\dot{q}_6\left(c_{q6}s_{q2}s_{q3}s_{q4}+\right.$$
$$\left.2c_{q3}s_{q2}s_{q5}s_{q6}+2c_{q4}c_{q5}s_{q2}s_{q3}s_{q6}\right)\Big)p_{16}\left(\dot{q}_2\left(2c_{q2}c_{q6}s_{q4}+c_{q2}c_{q3}s_{q5}s_{q6}+\right.\right.$$
$$2c_{q2}c_{q4}c_{q5}s_{q3}s_{q6}\Big)+\dot{q}_4\left(2c_{q4}c_{q6}s_{q2}-2c_{q5}s_{q2}s_{q3}s_{q4}s_{q6}\right)+\dot{q}_6\left(c_{q3}c_{q6}s_{q2}s_{q5}-\right.$$
$$2s_{q2}s_{q4}s_{q6}+2c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}\Big)+\dot{q}_3\left(2c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}-s_{q2}s_{q3}s_{q5}s_{q6}\right)+$$
$$\dot{q}_5\left(c_{q3}c_{q5}s_{q2}s_{q6}-2c_{q4}s_{q2}s_{q3}s_{q5}s_{q6}\right)p_{17}+\left(c_{q2}c_{q3}c_{q5}\dot{q}_2-c_{q3}\dot{q}_5s_{q2}s_{q5}-\right.$$
$$c_{q5}\dot{q}_3s_{q2}s_{q3}\Big)p_{18}+\left(c_{q2}\dot{q}_2s_{q3}+c_{q3}\dot{q}_3s_{q2}\right)p_{19}+\left(c_{q2}c_{q3}\dot{q}_2-\dot{q}_3s_{q2}s_{q3}\right)p_{20}+$$
$$\Big(\dot{q}_3\left(2c_{q3}^{\,2}s_{q4}s_{q6}-s_{q4}s_{q6}+c_{q4}c_{q5}c_{q6}+2c_{q3}c_{q6}s_{q3}s_{q5}-2c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}-\right.$$
$$c_{q3}c_{q4}c_{q6}s_{q2}+c_{q3}c_{q4}c_{q5}s_{q6}+c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}s_{q2}\Big)-\dot{q}_5\left(c_{q3}^{\,2}c_{q5}c_{q6}-c_{q3}c_{q4}c_{q6}s_{q3}s_{q5}+\right.$$
$$c_{q4}s_{q3}s_{q5}s_{q6}+2c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}s_{q5}\Big)+\dot{q}_6\left(s_{q5}s_{q6}c_{q3}^{\,2}+c_{q4}s_{q3}s_{q6}c_{q3}c_{q5}+c_{q6}s_{q3}s_{q4}c_{q3}-\right.$$
$$c_{q4}s_{q2}s_{q3}s_{q6}c_{q5}^{\,2}+c_{q4}c_{q6}s_{q3}c_{q5}+c_{q4}s_{q2}s_{q3}s_{q6}\Big)+\dot{q}_4\left(c_{q3}c_{q4}s_{q3}s_{q6}+c_{q6}s_{q2}s_{q3}s_{q4}-\right.$$
$$c_{q5}s_{q3}s_{q4}s_{q6}+c_{q3}c_{q5}c_{q6}s_{q3}s_{q4}-c_{q5}^{\,2}c_{q6}s_{q2}s_{q3}s_{q4}\Big)+\dot{q}_2\left(c_{q2}c_{q4}c_{q5}^{\,2}c_{q6}s_{q3}-\right.$$
$$c_{q2}c_{q4}c_{q6}s_{q3}\Big)p_{21}+\Big(\dot{q}_3\left(2c_{q3}^{\,2}c_{q6}s_{q4}-c_{q4}c_{q5}s_{q6}-c_{q6}s_{q4}-2c_{q3}s_{q3}s_{q5}s_{q6}+\right.$$
$$2c_{q3}^{\,2}c_{q4}c_{q5}s_{q6}+\dot{q}_6\left(c_{q3}^{\,2}c_{q6}s_{q5}-c_{q3}s_{q3}s_{q4}s_{q6}+c_{q3}c_{q4}c_{q5}c_{q6}s_{q3}\right)+\dot{q}_5\left(c_{q3}^{\,2}c_{q5}s_{q6}-\right.$$
$$c_{q3}c_{q4}s_{q3}s_{q5}s_{q6}\Big)+\dot{q}_4\left(c_{q3}c_{q4}c_{q6}s_{q3}-c_{q3}c_{q5}s_{q3}s_{q4}s_{q6}\right)\Big)p_{22}+\left(\dot{q}_3c_{q3}s_{q4}s_{q6}+\dot{q}_4c_{q4}s_{q3}s_{q6}+\right.$$
$$\dot{q}_6c_{q6}s_{q3}s_{q4}\Big)p_{23}+\left(c_{q3}c_{q6}\dot{q}_3s_{q4}-\dot{q}_2s_{q2}+c_{q4}c_{q6}\dot{q}_4s_{q3}-\dot{q}_6s_{q3}s_{q4}s_{q6}\right)p_{24}+$$
$$\Big(-\dot{q}_5\left(s_{q5}c_{q3}^{\,2}+c_{q4}c_{q5}s_{q3}c_{q3}\right)-\dot{q}_3\left(2c_{q3}^{\,2}c_{q4}s_{q5}+2c_{q3}c_{q5}s_{q3}-c_{q4}s_{q5}\right)+$$
$$\dot{q}_4c_{q3}s_{q3}s_{q4}s_{q5}\Big)p_{25}+\left(\dot{q}_3\left(2c_{q3}^{\,2}-1\right)\right)p_{27}+\tfrac{1}{2}\dot{q}_2c_{q2}p_{28}-\tfrac{1}{2}\dot{q}_3s_{q3}p_{29}-\tfrac{1}{2}\dot{q}_3s_{q3}p_{30}+$$
$$\tfrac{1}{2}c_{q3}\dot{q}_3p_{31}+\left(\dot{q}_4s_{q3}s_{q4}s_{q5}-\dot{q}_5\left(c_{q3}s_{q5}+c_{q4}c_{q5}s_{q3}\right)-\dot{q}_3\left(c_{q5}s_{q3}+c_{q3}c_{q4}s_{q5}\right)\right)p_{32}+$$
$$\Big(-\dot{q}_4\left(2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}-c_{q3}^{\,2}c_{q5}+c_{q3}c_{q4}s_{q3}s_{q5}\right)+\dot{q}_5\left(c_{q3}^{\,2}c_{q4}s_{q4}s_{q5}-c_{q3}c_{q5}s_{q3}s_{q4}\right)+$$
$$\dot{q}_3\left(-2s_{q4}s_{q5}c_{q3}^{\,2}+2c_{q4}c_{q5}s_{q3}s_{q4}c_{q3}+s_{q4}s_{q5}\right)\Big)p_{33}+\left(\dot{q}_4s_{q4}c_{q3}^{\,2}c_{q4}+\dot{q}_3s_{q3}c_{q3}c_{q4}^{\,2}\right)p_{34}+$$
$$\Big(\dot{q}_4\left(2c_{q4}s_{q4}s_{q5}c_{q3}^{\,2}c_{q5}+2s_{q3}s_{q4}c_{q3}c_{q5}^{\,2}\right)+\dot{q}_3\left(-4c_{q3}^{\,2}c_{q4}c_{q5}^{\,2}+2s_{q3}s_{q5}c_{q3}c_{q4}^{\,2}c_{q5}+\right.$$
$$2s_{q3}s_{q5}c_{q3}c_{q5}+2c_{q4}c_{q5}^{\,2}\Big)+\dot{q}_5\left(-2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}+c_{q3}^{\,2}c_{q4}^{\,2}-2c_{q3}^{\,2}c_{q5}^{\,2}+c_{q3}^{\,2}+\right.$$
$$4s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}+2c_{q5}^{\,2}-1\Big)p_{40}+\Big(\dot{q}_4\left(4s_{q5}c_{q3}^{\,2}c_{q4}^{\,2}-2s_{q5}c_{q3}^{\,2}+c_{q5}s_{q3}c_{q3}c_{q4}\right)+$$
$$\dot{q}_5\left(2c_{q3}^{\,2}c_{q4}c_{q5}s_{q4}-c_{q3}s_{q3}s_{q4}s_{q5}\right)-\dot{q}_3\left(-2c_{q3}^{\,2}c_{q5}s_{q4}+4c_{q3}c_{q4}s_{q3}s_{q4}s_{q5}+c_{q5}s_{q4}\right)\Big)p_{41}$$
$$+\left(\dot{q}_4\left(c_{q3}^{\,2}-2c_{q3}^{\,2}c_{q4}^{\,2}\right)+2c_{q3}c_{q4}\dot{q}_3s_{q3}s_{q4}\right)p_{42}+\left(\dot{q}_3\left(2c_{q3}^{\,2}s_{q4}-s_{q4}\right)+\dot{q}_4c_{q3}c_{q4}s_{q3}\right)p_{43}$$
$$+\left(\dot{q}_3\left(c_{q4}-2c_{q3}^{\,2}c_{q4}\right)+c_{q3}\dot{q}_4s_{q3}s_{q4}\right)p_{48}+\left(\dot{q}_2\left(1-2c_{q2}^{\,2}\right)\right)p_{49}$$

$$
\begin{aligned}
C_{12} = &\left(-\tfrac{1}{2}\dot{q}_1 s_{2q_2}\right)p_1 + \left(\tfrac{1}{2}\dot{q}_4 c_{q2} c_{q4}\ s_{q5} + \tfrac{1}{2}\dot{q}_5 c_{q2} c_{q5}\ s_{q4}\right)p_{15} + \left(\dot{q}_2\left(c_{q5} c_{q6} s_{q2} + \right.\right.\\
&\left.c_{q4} s_{q2} s_{q6}\right) - \left(\dot{q}_1\left(2c_{q2} c_{q3} c_{q6} s_{q5} - c_{q2} s_{q3} s_{q4} s_{q6} + 2c_{q2} c_{q4} c_{q5} c_{q6} s_{q3}\right) + \right.\\
&\dot{q}_5\left(\tfrac{1}{2} c_{q2} c_{q6} s_{q5} - \tfrac{1}{2} c_{q2} c_{q6} s_{q4} s_{q5}\right) + \dot{q}_6\left(\tfrac{1}{2} c_{q2} c_{q5} s_{q6} - \tfrac{1}{2} c_{q2} c_{q5} s_{q4} s_{q6}\right) + \\
&\left.\tfrac{1}{2}\dot{q}_4 c_{q2} c_{q4} c_{q5} c_{q6}\right)\Big)p_{16} + \left(\dot{q}_1\left(2c_{q2} c_{q6} s_{q4} + c_{q2} c_{q3} s_{q5} s_{q6} + 2c_{q2} c_{q4} c_{q5} s_{q3} s_{q6}\right) + \right.\\
&\left(\dot{q}_2\left(c_{q4} c_{q6} s_{q2} + c_{q5} s_{q2} s_{q4} s_{q6}\right) - \dot{q}_4 c_{q2} c_{q4} c_{q5}\ s_{q6} - \dot{q}_6 c_{q2} c_{q5} c_{q6}\ s_{q4}\right. \qquad \text{(B.75)}\\
&\left.+ \dot{q}_5 c_{q2}\ s_{q4} s_{q5} s_{q6}\right)p_{17} + \left(\dot{q}_2 s_{q2} s_{q4} s_{q5} - \tfrac{1}{2}\dot{q}_5 c_{q2} c_{q5}\ s_{q4} - \tfrac{1}{2}\dot{q}_4 c_{q2} c_{q4}\ s_{q5} + \right.\\
&\left.\dot{q}_1 c_{q2} c_{q3} c_{q5}\right)p_{18} + \left(c_{q2}\dot{q}_1 s_{q3}\right)p_{19} + \left(c_{q2} c_{q3}\dot{q}_1\right)p_{20} - \\
&\left(c_{q2} c_{q4} c_{q6} s_{q3} + c_{q2} c_{q4} {c_{q5}}^2 c_{q6} s_{q3}\right)\dot{q}_1 p_{21} - \dot{q}_1 s_{q2}\ p_{24} + \tfrac{1}{2} c_{q2}\dot{q}_1 p_{28} \\
&-\dot{q}_2 s_{q2}\ p_{45} - c_{q2}\dot{q}_2 p_{46} - \left(2{c_{q2}}^2 - 1\right)\dot{q}_1 p_{49}
\end{aligned}
$$

$$
\begin{aligned}
C_{13} = &\left(\dot{q}_1\left(c_{q6} s_{q5} - \tfrac{1}{2} s_{2q_3} - s_{q5} s_{q6} + 2{c_{q3}}^2 s_{q5} s_{q6} + c_{q6} s_{q3} s_{q5} - 2{c_{q3}}^2 c_{q6} s_{q5} + \right.\right.\\
&\left.2c_{q3} s_{q3} s_{q4} s_{q6}\right) + \dot{q}_4\left(\tfrac{1}{2} c_{q3} s_{q4} s_{q6} - \tfrac{1}{2} c_{q3} c_{q6} s_{q4} + \tfrac{1}{2} c_{q4} c_{q5} c_{q6} s_{q3}\right) + \dot{q}_3\left(c_{q4} s_{q3} s_{q6} + \right.\\
&\left.c_{q5} c_{q6} s_{q3} s_{q4} + c_{q3} c_{q5} c_{q6} s_{q4}\right) - \tfrac{1}{2}\dot{q}_5 c_{q6}\ s_{q3} s_{q4} s_{q5} - \tfrac{1}{2}\dot{q}_6 c_{q5}\ s_{q3} s_{q4} s_{q6}\Big)\Big)p_5 \\
&\left(\dot{q}_1\left(4c_{q3} c_{q6} s_{q3} s_{q4} - 2s_{q3} s_{q5} s_{q6} + 4c_{q3} c_{q4} c_{q5} s_{q3} s_{q6}\right) + \dot{q}_3\left(c_{q4} c_{q6} s_{q3} - \right.\right.\\
&\left.c_{q5} s_{q3} s_{q4} s_{q6}\right)\Big)p_6 + \left(-\dot{q}_1\left(-2c_{q5} {c_{q3}}^2 + 2c_{q4} s_{q3} s_{q5} c_{q3} + c_{q5}\right) + \dot{q}_3 s_{q3} s_{q4} s_{q5}\right)p_7 + \\
&\left(-\dot{q}_4\left(c_{q3} {c_{q4}}^2 {c_{q5}}^2 {c_{q6}}^2 - c_{q3} s_{q5} s_{q6} {c_{q4}}^2 c_{q5} + \tfrac{1}{2} s_{q3} s_{q6} c_{q4} {c_{q5}}^2 - 2c_{q3} s_{q4} s_{q5} c_{q4} c_{q6} - \right.\right.\\
&\tfrac{1}{2} c_{q3} {c_{q5}}^2 {c_{q6}}^2 + \tfrac{1}{2} s_{q3} s_{q4} c_{q5} c_{q6} + \tfrac{1}{2} 3c_{q3} s_{q5} s_{q6} c_{q5}\Big) + \dot{q}_6\left(c_{q3} s_{q5} s_{q6} {c_{q4}}^2 + \right.\\
&c_{q3} c_{q6} s_{q4} s_{q6} c_{q4} {c_{q5}}^2 + \tfrac{1}{2} c_{q3} c_{q6} s_{q4} s_{q5} c_{q4} c_{q5} + \tfrac{1}{2} c_{q6} s_{q3} s_{q4} {c_{q5}}^2 - c_{q6} s_{q3} s_{q4} - \\
&\left.c_{q3} s_{q5} s_{q6}\right) - \dot{q}_3\left(-2s_{q3} s_{q5} {c_{q4}}^2 c_{q6} - s_{q3} s_{q4} c_{q4} {c_{q5}}^2 {c_{q6}}^2 + c_{q3} c_{q4} c_{q5} c_{q6} + \right.\\
&\left.s_{q3} s_{q4} s_{q5} s_{q6} c_{q4} c_{q5} - c_{q3} s_{q4} s_{q6} {c_{q5}}^2 + s_{q3} s_{q5} c_{q6} + c_{q3} s_{q4} s_{q6}\right) + \\
&\dot{q}_1\left(-4s_{q6} {c_{q3}}^2 c_{q4} {c_{q5}}^2 + s_{q6} {c_{q3}}^2 c_{q4} - 2c_{q6} s_{q4} {c_{q3}}^2 c_{q5} + s_{q3} s_{q5} s_{q6} c_{q3} {c_{q4}}^2 c_{q5} + \right.\\
&c_{q6} s_{q3} s_{q4} s_{q5} c_{q3} c_{q4} + 2s_{q3} s_{q5} s_{q6} c_{q3} c_{q5} + 2s_{q6} c_{q4} {c_{q5}}^2 - \tfrac{1}{2} s_{q6} c_{q4} + c_{q6} s_{q4} c_{q5}\Big) - \\
&\dot{q}_5\left(c_{q3} {c_{q4}}^2 c_{q5} c_{q6} - c_{q3} s_{q4} s_{q6} c_{q4} {c_{q5}}^2 - c_{q3} s_{q4} s_{q5} c_{q4} c_{q5} {c_{q6}}^2 - s_{q3} s_{q5} c_{q4} c_{q6} + \right.\\
&\left.\tfrac{1}{2} c_{q3} s_{q4} s_{q6} c_{q4} + \tfrac{1}{2} c_{q3} c_{q5} c_{q6} + s_{q3} s_{q4} s_{q5} s_{q6} c_{q5}\Big)\Big)p_{11} + \left(\dot{q}_5\ c_{q3} s_{q5} s_{q6} {c_{q4}}^2 c_{q6} - \right.\\
&\tfrac{1}{2} s_{q3} s_{q5} c_{q4} c_{q5} {c_{q6}}^2 + s_{q3} s_{q6} c_{q4} c_{q5} c_{q6} + s_{q3} s_{q4} {c_{q5}}^2 c_{q6}^2 - \tfrac{1}{2} s_{q3} s_{q4} {c_{q6}}^2\Big) - \\
&\left(\dot{q}_6\left(2c_{q3} c_{q5} {c_{q4}}^2 {c_{q6}}^2 - c_{q3} c_{q5} {c_{q4}}^2 - s_{q3} s_{q5} c_{q4} {c_{q6}}^2 - c_{q3} s_{q4} s_{q6} c_{q4} c_{q6} + \right.\right.\\
&\tfrac{1}{2} s_{q3} s_{q5} c_{q4} - c_{q3} c_{q5} {c_{q6}}^2 + c_{q5} s_{q3} s_{q4} s_{q5} s_{q6} c_{q6} + \tfrac{1}{2} c_{q3} c_{q5}\Big) - \dot{q}_1\left(\tfrac{1}{2} {c_{q4}}^2 {c_{q5}}^2 {c_{q6}}^2 s_{q3} - \right.\\
&2c_{q3} {c_{q6}}^2 s_{q3} + c_{q6} s_{q4} s_{q5} s_{q6} - c_{q4} c_{q5} c_{q6}^2 s_{q5} + c_{q3} {c_{q4}}^2 c_{q6}^2 s_{q3} + c_{q3} {c_{q5}}^2 c_{q6}^2 s_{q3} + \\
&c_{q3} c_{q4} c_{q5} c_{q6} + 2{c_{q3}}^2 c_{q4} c_{q5} {c_{q6}}^2 s_{q5} - 2{c_{q3}}^2 c_{q6} s_{q4} s_{q5} s_{q6} - \\
&\left.2c_{q3} c_{q4} c_{q5} c_{q6} s_{q3} s_{q4} s_{q6}\right) + \dot{q}_4\left(-c_{q3} {c_{q4}}^2 {c_{q6}}^2 + 2c_{q3} s_{q4} s_{q6} c_{q4} c_{q5} c_{q6} - \tfrac{1}{2}\dot{q}_1 s_{q3}\right) + \\
&\dot{q}_3\left(2c_{q5} s_{q3} s_{q6} {c_{q4}}^2 c_{q6} + s_{q3} s_{q4} c_{q4} {c_{q6}}^2 + c_{q3} s_{q5} s_{q6} c_{q4} c_{q6} + c_{q3} c_{q5} s_{q4} s_{q5} {c_{q6}}^2 - \right. \qquad \text{(B.76)}\\
&\left.c_{q5} s_{q3} s_{q6} c_{q6}\right)\Big)p_{12} + \left(\dot{q}_3\left(c_{q4} s_{q3} s_{q4} {c_{q5}}^2 + c_{q3} s_{q4} s_{q5} c_{q5}\right) - \dot{q}_1\left(s_{q5} {c_{q3}}^2 c_{q4} c_{q5} + \right.\right.\\
&s_{q3} c_{q3} {c_{q4}}^2 {c_{q5}}^2 + s_{q3} c_{q3} {c_{q5}}^2 - \tfrac{1}{2} s_{q5} c_{q4} c_{q5}\Big) + \dot{q}_5 s\left(_{q3} s_{q4} {c_{q5}}^2 + c_{q3} c_{q4} s_{q4} s_{q5} c_{q5} - \right.\\
&\left.\tfrac{1}{2} s_{q3} s_{q4}\right) + \dot{q}_4\left(c_{q3} {c_{q5}}^2 - c_{q3} {c_{q4}}^2 {c_{q5}}^2\right)\Big)p_{13} + \left(\dot{q}_5\left(2c_{q3} s_{q5} {c_{q4}}^2 {c_{q6}}^2 + \right.\right.\\
&s_{q3} c_{q4} c_{q5} {c_{q6}}^2 + \tfrac{1}{2} s_{q3} c_{q4} c_{q5} c_{q6} - 2s_{q3} s_{q4} s_{q6} {c_{q5}}^2 c_{q6} - \tfrac{1}{2} c_{q3} s_{q5} {c_{q6}}^2\Big) - \\
&\dot{q}_3\left(2c_{q5} c_{q6}^2 s_{q3} - 4{c_{q4}}^2 c_{q5} c_{q6}^2 s_{q3} - c_{q3} c_{q4} c_{q6} s_{q5} + 3c_{q4} c_{q6} s_{q3} s_{q4} s_{q6} + \right.
\end{aligned}
$$

$$2c_{q3}c_{q5}c_{q6}s_{q4}s_{q5}s_{q6}\big)+\dot{q}_1\big(4s_{q5}s_{q6}c_{q3}{}^2c_{q4}c_{q5}c_{q6}+4s_{q4}s_{q5}c_{q3}{}^2c_{q6}{}^2+$$
$$2s_{q3}s_{q6}c_{q3}c_{q4}{}^2c_{q5}{}^2c_{q6}+4s_{q3}s_{q4}c_{q3}c_{q4}c_{q5}c_{q6}{}^2+2s_{q3}s_{q6}c_{q3}c_{q5}{}^2c_{q6}-$$
$$4s_{q3}s_{q6}c_{q3}c_{q6}-2s_{q5}s_{q6}c_{q4}c_{q5}c_{q6}-2s_{q4}s_{q5}c_{q6}{}^2\big)+\dot{q}_4\big(\tfrac{1}{2}c_{q3}c_{q6}s_{q6}-$$
$$\tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5}+3c_{q3}c_{q4}{}^2c_{q6}s_{q6}-2c_{q3}c_{q5}{}^2c_{q6}s_{q6}+2c_{q6}{}^2s_{q3}s_{q4}s_{q5}+$$
$$4c_{q3}c_{q4}c_{q5}c_{q6}{}^2s_{q4}+c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}s_{q6}\big)-\dot{q}_6\big(\tfrac{3}{2}c_{q3}c_{q4}s_{q4}-c_{q5}s_{q3}s_{q4}s_{q5}+$$
$$\tfrac{1}{2}c_{q4}s_{q3}s_{q5}s_{q6}-3c_{q3}c_{q4}c_{q6}{}^2s_{q4}+2c_{q3}c_{q5}c_{q6}s_{q6}-4c_{q3}c_{q4}{}^2c_{q5}c_{q6}s_{q6}+$$
$$2c_{q5}c_{q6}{}^2s_{q3}s_{q4}s_{q5}\big)\big)p_{14}+\big(-\dot{q}_4\big(\tfrac{1}{2}c_{q4}c_{q6}s_{q3}-2c_{q3}c_{q5}c_{q6}s_{q5}-$$
$$2c_{q3}c_{q4}s_{q4}s_{q5}s_{q6}+2c_{q3}c_{q4}{}^2c_{q5}c_{q6}s_{q5}\big)-\dot{q}_3\big(c_{q3}c_{q6}s_{q4}+s_{q3}s_{q5}s_{q6}+$$
$$c_{q3}c_{q5}{}^2c_{q6}s_{q4}-2c_{q4}{}^2s_{q3}s_{q5}s_{q6}+c_{q3}c_{q4}c_{q5}s_{q6}-2c_{q4}c_{q5}c_{q6}s_{q3}s_{q4}s_{q5}\big)+$$
$$\dot{q}_1\big(2c_{q3}{}^2c_{q4}c_{q5}{}^2c_{q6}-2s_{q4}s_{q6}c_{q3}{}^2c_{q5}-2s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}{}^2c_{q5}c_{q6}{}^2-$$
$$2s_{q3}s_{q5}c_{q3}c_{q4}{}^2c_{q5}c_{q6}+2s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}c_{q4}-2s_{q3}s_{q5}c_{q3}c_{q5}c_{q6}-c_{q4}c_{q5}{}^2c_{q6}+$$
$$s_{q4}s_{q6}c_{q5}\big)+\dot{q}_6-\big(c_{q3}c_{q6}s_{q5}c_{q4}{}^2+c_{q3}s_{q4}s_{q5}s_{q6}c_{q4}c_{q5}+\tfrac{1}{2}s_{q3}s_{q4}s_{q6}c_{q5}{}^2+$$
$$c_{q3}c_{q6}s_{q5}\big)+\dot{q}_5\big(c_{q4}s_{q3}s_{q5}s_{q6}-c_{q3}c_{q4}{}^2c_{q5}s_{q6}+c_{q3}c_{q4}c_{q6}s_{q4}+$$
$$c_{q5}c_{q6}s_{q3}s_{q4}s_{q5}-2c_{q3}c_{q4}c_{q5}{}^2c_{q6}s_{q4}\big)\big)p_{15}+\big(\dot{q}_1\big(c_{q3}s_{q2}s_{q4}s_{q6}+2c_{q6}s_{q2}s_{q3}s_{q5}$$
$$-2c_{q3}c_{q4}c_{q5}c_{q6}s_{q2}\big)p_{16}-\big(s_{q2}s_{q3}s_{q5}s_{q6}-2c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}\big)\dot{q}_1p_{17}-$$
$$\big(c_{q5}\dot{q}_1s_{q2}s_{q3}\big)p_{18}+\big(c_{q3}\dot{q}_1s_{q2}\big)p_{19}+\big(-\dot{q}_1s_{q2}s_{q3}\big)p_{20}+\big(\dot{q}_1\big(2c_{q3}{}^2s_{q4}s_{q6}-$$
$$s_{q4}s_{q6}+c_{q4}c_{q5}c_{q6}+2c_{q3}c_{q6}s_{q3}s_{q5}-2c_{q3}{}^2c_{q4}c_{q5}c_{q6}-c_{q3}c_{q4}c_{q6}s_{q2}+c_{q3}c_{q4}c_{q5}s_{q6}+$$
$$c_{q3}c_{q4}c_{q5}{}^2c_{q6}s_{q2}\big)+\dot{q}_3c_{q3}c_{q4}s_{q6}-\tfrac{1}{2}\dot{q}_4c_{q4}c_{q5}c_{q6}s_{q3}+\tfrac{1}{2}\dot{q}_5c_{q6}s_{q3}s_{q4}s_{q5}+$$
$$\dot{q}_6\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\big)p_{21}+\big(\dot{q}_3\big(c_{q3}c_{q4}c_{q6}-c_{q3}c_{q5}s_{q4}s_{q6}\big)-\dot{q}_1\big(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}-$$
$$2c_{q3}{}^2c_{q6}s_{q4}+2c_{q3}s_{q3}s_{q5}s_{q6}-$$
$$2c_{q3}{}^2c_{q4}c_{q5}s_{q6}\big)\big)p_{22}+\big(c_{q3}\dot{q}_1s_{q4}s_{q6}\big)p_{23}+\big(c_{q3}c_{q6}\dot{q}_1s_{q4}\big)p_{24}-\dot{q}_1\big(2c_{q4}s_{q5}c_{q3}{}^2+$$
$$2c_{q5}s_{q3}c_{q3}-c_{q4}s_{q5}\big)+\dot{q}_3c_{q3}s_{q4}s_{q5}\big)p_{25}+\big(\dot{q}_1\big(2c_{q3}{}^2-1\big)\big)p_{27}-\tfrac{1}{2}\dot{q}_1s_{q3}p_{29}-$$
$$\tfrac{1}{2}\dot{q}_1s_{q3}p_{30}+\tfrac{1}{2}\dot{q}_1c_{q3}p_{31}-\dot{q}_1\big(c_{q5}s_{q3}+c_{q3}c_{q4}s_{q5}\big)p_{32}+\big(\dot{q}_5\big(c_{q3}s_{q5}c_{q4}{}^2+c_{q5}s_{q3}c_{q4}\big)+$$
$$\dot{q}_1\big(-2s_{q4}s_{q5}c_{q3}{}^2+2c_{q4}c_{q5}s_{q3}s_{q4}c_{q3}+s_{q4}s_{q5}\big)+\dot{q}_3\big(2c_{q5}s_{q3}c_{q4}{}^2+c_{q3}s_{q5}c_{q4}-c_{q5}s_{q3}\big)+$$
$$2c_{q3}c_{q4}c_{q5}\dot{q}_4s_{q4}\big)\big)p_{33}+\big(\dot{q}_1c_{q3}c_{q4}{}^2s_{q3}-\dot{q}_3c_{q4}s_{q3}s_{q4}-\dot{q}_4\big(\tfrac{1}{2}c_{q3}-c_{q3}c_{q4}{}^2\big)\big)p_{34}+$$
$$\big(-\tfrac{1}{2}\dot{q}_4c_{q3}\big)p_{35}-\tfrac{1}{2}\dot{q}_5s_{q3}s_{q4}p_{36}-\dot{q}_6\tfrac{1}{2}\big(c_{q3}c_{q5}-c_{q4}s_{q3}s_{q5}\big)p_{37}+\big(\dot{q}_3\,2\big(c_{q3}c_{q5}s_{q4}-$$
$$4c_{q4}c_{q5}s_{q3}s_{q4}s_{q5}\big)+\dot{q}_4\big(4c_{q3}s_{q5}c_{q4}{}^2c_{q5}-s_{q3}c_{q4}c_{q5}{}^2+s_{q3}c_{q4}c_{q5}-4c_{q3}s_{q5}c_{q5}\big)-$$
$$\dot{q}_1\big(4c_{q3}{}^2c_{q4}c_{q5}{}^2-2s_{q3}s_{q5}c_{q3}c_{q4}{}^2c_{q5}-2s_{q3}s_{q5}c_{q3}c_{q5}-2c_{q4}c_{q5}{}^2\big)+\dot{q}_5\big(4c_{q3}c_{q4}s_{q4}c_{q5}{}^2-$$
$$2c_{q3}c_{q4}s_{q4}-s_{q3}s_{q4}s_{q5}\big)\big)p_{40}+\big(\dot{q}_3\big(-2s_{q3}s_{q5}c_{q4}{}^2+c_{q3}c_{q5}c_{q4}+s_{q3}s_{q5}\big)-\dot{q}_5\big(c_{q4}s_{q3}s_{q5}-$$
$$c_{q3}c_{q4}{}^2c_{q5}\big)+\dot{q}_1\big(2c_{q5}s_{q4}c_{q3}{}^2-4c_{q4}s_{q3}s_{q4}s_{q5}c_{q3}-c_{q5}s_{q4}\big)-2\,\dot{q}_4c_{q3}c_{q4}s_{q4}s_{q5}\big)p_{41}+$$
$$\big(2\dot{q}_3c_{q4}{}^2s_{q3}+2\,\dot{q}_4c_{q3}c_{q4}s_{q4}+\dot{q}_1\,2c_{q3}c_{q4}s_{q3}s_{q4}\big)p_{42}+\big(c_{q3}c_{q4}\dot{q}_3-$$
$$\dot{q}_1\big(s_{q4}-2c_{q3}{}^2s_{q4}\big)\big)p_{43}-c_{q3}\dot{q}_3p_{44}+\big(\dot{q}_1\big(c_{q4}-2c_{q3}{}^2c_{q4}\big)+c_{q3}\dot{q}_3s_{q4}\big)p_{48}-\dot{q}_3s_{q3}p_{50}$$

$$C_{14} = \left(\dot{q}_3 \tfrac{1}{2}\left(c_{q3}s_{q4}s_{q6} - c_{q3}c_{q6}s_{q4} + c_{q4}c_{q5}c_{q6}s_{q3}\right) - \dot{q}_6\left(\tfrac{1}{2}c_{q6}s_{q3}s_{q4} - \tfrac{1}{2}s_{q3}s_{q4}s_{q6} + c_{q4}c_{q5}s_{q3}s_{q6}\right) - \dot{q}_4\left(c_{q4}c_{q6}s_{q3} + c_{q5}c_{q6}s_{q3}s_{q4}\right) + \dot{q}_1\left(c_{q4}s_{q6} - c_{q4}s_{q6}{c_{q3}}^2 + c_{q5}c_{q6}s_{q4}\right) - \dot{q}_5 c_{q4}c_{q6}s_{q3}s_{q5}\right)p_5 + \left(\dot{q}_1\left(2c_{q4}c_{q6} - c_{q5}s_{q4}s_{q6} - 2{c_{q3}}^2 c_{q4}c_{q6} + 2{c_{q3}}^2 c_{q5}s_{q4}s_{q6}\right) - \dot{q}_4\left(c_{q4}c_{q6}s_{q3} - c_{q5}s_{q3}s_{q4}s_{q6}\right) + \dot{q}_6\left(s_{q3}s_{q4}s_{q6} - c_{q4}c_{q5}c_{q6}s_{q3}\right) + \dot{q}_5\, c_{q4}\, s_{q3}s_{q5}s_{q6}\right)p_6 + \left(\dot{q}_4\left(2c_{q3}c_{q4}c_{q6}c_{q5} - 2c_{q3}s_{q4}s_{q6}{c_{q5}}^2 + c_{q3}s_{q4}s_{q6}\right) - \dot{q}_3\left(c_{q3}{c_{q4}}^2{c_{q5}}^2{c_{q6}}^2 - c_{q3}s_{q5}s_{q6}{c_{q4}}^2c_{q5} + \tfrac{1}{2}s_{q3}s_{q6}c_{q4}{c_{q5}}^2 - 2c_{q3}s_{q4}s_{q5}c_{q4}c_{q6} - \tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2 + \tfrac{1}{2}s_{q3}s_{q4}c_{q5}c_{q6} + \tfrac{3}{2}c_{q3}s_{q5}s_{q6}c_{q5}\right) + \dot{q}_1\left(s_{q4}s_{q5}s_{q6}{c_{q3}}^2c_{q4}c_{q5} - c_{q6}s_{q5}{c_{q3}}^2{c_{q4}}^2 + \tfrac{1}{2}c_{q6}s_{q5}{c_{q3}}^2 - c_{q6}s_{q3}c_{q3}c_{q4}c_{q5} + 2s_{q3}s_{q4}s_{q6}c_{q3}{c_{q5}}^2 - \tfrac{1}{2}s_{q3}s_{q4}s_{q6}c_{q3}\right) - \dot{q}_6\tfrac{3}{2}c_{q3}c_{q5}s_{q4}s_{q6} + c_{q5}c_{q6}s_{q3}s_{q5} - c_{q3}c_{q4}{c_{q5}}^2c_{q6}\right) - \dot{q}_5\left(2s_{q3}s_{q6}{c_{q5}}^2 + 2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5} - s_{q3}s_{q6} + \tfrac{1}{2}c_{q3}c_{q6}s_{q4}s_{q5}\right)\right)p_{11} + \left(-\dot{q}_5\left(\tfrac{1}{2}c_{q3}c_{q4}{c_{q6}}^2 + c_{q5}{c_{q6}}^2s_{q3}s_{q5} - c_{q3}c_{q4}{c_{q5}}^2{c_{q6}}^2 + \tfrac{1}{2}c_{q3}c_{q5}{c_{q6}}^2s_{q4}s_{q5}\right) - \dot{q}_6\left(s_{q3}s_{q6}{c_{q5}}^2c_{q6} + c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6} + c_{q3}s_{q4}s_{q5}{c_{q6}}^2 - s_{q3}s_{q6}c_{q6} - \tfrac{1}{2}c_{q3}s_{q4}s_{q5}\right) - \dot{q}_4\left(c_{q3}c_{q5}s_{q4}s_{q5}{c_{q6}}^2 + c_{q3}c_{q4}s_{q5}s_{q6}c_{q6}\right) + \dot{q}_3\left(2c_{q3}s_{q4}s_{q6}c_{q4}c_{q5}c_{q6} - c_{q3}{c_{q4}}^2{c_{q6}}^2 + \tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2\right) + \dot{q}_1\left(s_{q6}{c_{q3}}^2c_{q5}c_{q6} - 2s_{q6}{c_{q3}}^2{c_{q4}}^2c_{q5}c_{q6} - s_{q4}{c_{q3}}^2c_{q4}{c_{q6}}^2 - s_{q4}c_{q3}c_{q4}{c_{q5}}^2{c_{q6}}^2 + s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}c_{q6} + s_{q3}s_{q4}s_{q5}c_{q3}c_{q5}{c_{q6}}^2 + s_{q3}s_{q4}c_{q5}c_{q6}\right)\right)p_{12} + \left(\tfrac{1}{2}\dot{q}_6 s_{2q_6} - \dot{q}_1\left(c_{q3}{}^2c_{q4}{c_{q5}}^2s_{q4} - \tfrac{1}{2}c_{q3}c_{q5}s_{q3}s_{q4}s_{q5}\right) - \dot{q}_5\left(-c_{q3}c_{q4}{c_{q5}}^2 + s_{q3}s_{q5}c_{q5} + \tfrac{1}{2}c_{q3}c_{q4}\right) + \dot{q}_3\left(c_{q3}c_{q5}{}^2 - c_{q3}{c_{q4}}^2{c_{q5}}^2\right) - c_{q3}c_{q5}\dot{q}_4 s_{q4}s_{q5}\right)p_{13} + \left(\dot{q}_1\left(2s_{q4}s_{q6}{c_{q3}}^2{c_{q4}}{c_{q5}}^2c_{q6} - 4{c_{q3}}^2{c_{q4}}^2c_{q5}{c_{q6}}^2 + 2{c_{q3}}^2c_{q5}{c_{q6}}^2 + 2s_{q3}s_{q5}c_{q3}c_{q4}{c_{q6}}^2 - 2s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}c_{q5}c_{q6}\right) - \dot{q}_4\left(4c_{q3}c_{q4}{c_{q6}}^2s_{q5} - 4c_{q3}c_{q5}c_{q6}s_{q4}s_{q5}s_{q6}\right) + \dot{q}_3\tfrac{1}{2}c_{q3}c_{q6}s_{q6} - \tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5} + 3c_{q3}{c_{q4}}^2c_{q6}s_{q6} - 2c_{q3}{c_{q5}}^2c_{q6}s_{q6} + 2c_{q6}{}^2s_{q3}s_{q4}s_{q5} + 4c_{q3}c_{q4}c_{q5}{c_{q6}}^2s_{q4} + c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}s_{q6}\right) + \dot{q}_6\left(2s_{q3}{c_{q5}}^2 - 4s_{q3}{c_{q5}}^2{c_{q6}}^2 - 4c_{q3}c_{q4}s_{q5}c_{q5}{c_{q6}}^2 + 2c_{q3}c_{q4}s_{q5}c_{q5} + 4s_{q3}{c_{q6}}^2 + 4c_{q3}s_{q4}s_{q5}s_{q6}c_{q6} - 2s_{q3}\right) - \dot{q}_5\left(4c_{q3}c_{q4}s_{q6}{c_{q5}}^2c_{q6} + c_{q3}s_{q4}c_{q5}{c_{q6}}^2 - 4s_{q3}s_{q5}s_{q6}c_{q5}c_{q6} - 3c_{q3}c_{q4}s_{q6}c_{q6}\right)\right)p_{14} + \left(-\dot{q}_3\left(2c_{q3}c_{q5}c_{q6}s_{q5} + 2c_{q3}c_{q4}s_{q4}s_{q5}s_{q6} - 2c_{q3}{c_{q4}}^2c_{q5}c_{q6}s_{q5} - \tfrac{1}{2}c_{q4}c_{q6}s_{q3}\right) + \dot{q}_6\left(\tfrac{1}{2}c_{q3}c_{q4}s_{q6} - c_{q5}s_{q3}s_{q5}s_{q6} + \tfrac{1}{2}c_{q3}c_{q4}{c_{q5}}^2s_{q6} + c_{q3}c_{q5}c_{q6}s_{q4}\right) + \dot{q}_4\left(c_{q3}c_{q6}s_{q4}{c_{q5}}^2 + c_{q3}c_{q4}s_{q6}c_{q5} - s_{q2}s_{q4}s_{q5}\right) + \dot{q}_5\left(c_{q4}c_{q5}s_{q2} - c_{q6}s_{q3} + 2{c_{q5}}^2c_{q6}s_{q3} + c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}\right) - \dot{q}_1\left(2s_{q5}s_{q6}{c_{q3}}^2{c_{q4}}^2 + 2s_{q4}s_{q5}s_{q6}{c_{q3}}^2c_{q4}c_{q5}c_{q6}{}^2 + 2s_{q4}s_{q5}{c_{q3}}^2c_{q4}c_{q5}c_{q6} - s_{q5}s_{q6}{c_{q3}}^2 + s_{q3}s_{q6}c_{q3}c_{q4}c_{q5} + s_{q3}s_{q4}c_{q3}{c_{q5}}^2c_{q6}\right) + \tfrac{1}{2}\dot{q}_2 c_{q2}c_{q4}\, s_{q5}\right)p_{15} + \left(\dot{q}_1\left(c_{q4}s_{q2}s_{q3}s_{q6} + 2c_{q5}c_{q6}s_{q2}s_{q3}s_{q4}\right) - \dot{q}_4\left(c_{q4}s_{q2}s_{q6} + c_{q5}c_{q6}s_{q2}s_{q4}\right) - \dot{q}_6\left(c_{q6}s_{q2}s_{q4} + c_{q4}c_{q5}s_{q2}s_{q6}\right) + \tfrac{1}{2}c_{q2}c_{q4}c_{q5}c_{q6}\dot{q}_2 - c_{q4}c_{q6}\dot{q}_5 s_{q2}s_{q5}\right)p_{16} + \left(\dot{q}_1\left(2c_{q4}c_{q6}s_{q2} - 2c_{q5}s_{q2}s_{q3}s_{q4}s_{q6}\right) - \dot{q}_4\left(c_{q4}c_{q6}s_{q2} - c_{q5}s_{q2}s_{q4}s_{q6}\right) + \dot{q}_6\left(s_{q2}s_{q4}s_{q6} - c_{q4}c_{q5}c_{q6}s_{q2}\right) - \dot{q}_2 c_{q2}c_{q4}c_{q5}\, s_{q6} + \dot{q}_5\, c_{q4}\, s_{q2}s_{q5}s_{q6}\right)p_{17} - \tfrac{1}{2}\dot{q}_2 c_{q2}\, c_{q4}\, s_{q5}\, p_{18} + \left(\dot{q}_1\left(c_{q3}c_{q4}s_{q3}s_{q6} + c_{q6}s_{q2}s_{q3}s_{q4} - c_{q5}s_{q3}s_{q4}s_{q6} + c_{q3}c_{q5}c_{q6}s_{q3}s_{q4} - {c_{q5}}^2c_{q6}s_{q2}s_{q3}s_{q4}\right) - \dot{q}_6\left(c_{q3}c_{q6}s_{q4} + c_{q3}c_{q4}c_{q5}s_{q6}\right) - \dot{q}_4\left(c_{q3}c_{q4}s_{q6} + c_{q3}c_{q5}c_{q6}s_{q4}\right) - \tfrac{1}{2}c_{q4}c_{q5}c_{q6}\dot{q}_3 s_{q3} - c_{q3}c_{q4}c_{q6}\dot{q}_5 s_{q5}\right)p_{21} + \left(\dot{q}_1\left(c_{q3}c_{q4}c_{q6}s_{q3} - c_{q3}c_{q5}s_{q3}s_{q4}s_{q6}\right) - \dot{q}_4\left(c_{q3}c_{q4}c_{q6} - c_{q3}c_{q5}s_{q4}s_{q6}\right) + \right. \tag{B.77}$$

$$\dot{q}_6\left(c_{q3}\,s_{q4}\,s_{q6}-c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\right)+\dot{q}_5\,c_{q3}\,c_{q4}\,s_{q5}\,s_{q6}\,\big)p_{22}+$$
$$\left(\dot{q}_1 c_{q4}\,s_{q3}\,s_{q6}-\dot{q}_6\left(c_{q6}\,s_{q4}+c_{q4}\,c_{q5}\,s_{q6}\right)-c_{q4}\,c_{q6}\,\dot{q}_5\,s_{q5}-\dot{q}_4\left(c_{q4}\,s_{q6}+c_{q5}\,c_{q6}\,s_{q4}\right)\right)p_{23}+$$
$$\left(\dot{q}_6\left(\tfrac{1}{2}c_{q4}\,c_{q6}+\tfrac{1}{2}s_{q4}\,s_{q6}-c_{q4}\,c_{q5}\,c_{q6}\right)-\dot{q}_4\left(s_{q4}\,s_{q6}-c_{q5}\,s_{q4}\,s_{q6}\right)+c_{q4}\,c_{q6}\,\dot{q}_1\,s_{q3}+\right.$$
$$\left.c_{q4}\,\dot{q}_5\,s_{q5}\,s_{q6}\right)p_{24}+\left(\dot{q}_5 c_{q3}\,c_{q4}\,c_{q5}-\dot{q}_4 c_{q3}\,s_{q4}\,s_{q5}+\dot{q}_1 c_{q3}\,s_{q3}\,s_{q4}\,s_{q5}\right)p_{25}+\left(\tfrac{3}{2}\dot{q}_5 c_{q4}\,c_{q5}-\right.$$
$$\left.2\dot{q}_4\,s_{q4}\,s_{q5}+\dot{q}_1\,s_{q3}\,s_{q4}\,s_{q5}\right)p_{32}+\left(\dot{q}_1\left(c_{q5}\,{c_{q3}}^2-2c_{q5}\,{c_{q3}}^2\,{c_{q4}}^2-s_{q3}\,s_{q5}\,c_{q3}\,c_{q4}\right)-\dot{q}_4 c_{q3}\,c_{q4}\,s_{q5}+\right.$$
$$\left.2\dot{q}_3\,c_{q3}\,c_{q4}\,c_{q5}\,s_{q4}\right)p_{33}+\left(c_{q3}{}^2\,c_{q4}\,\dot{q}_1\,s_{q4}-\dot{q}_3\left(\tfrac{1}{2}c_{q3}-c_{q3}\,{c_{q4}}^2\right)\right)p_{34}-\tfrac{1}{2}c_{q3}\,\dot{q}_3 p_{35}+$$
$$\tfrac{1}{2}c_{q3}\,c_{q4}\,\dot{q}_5\,p_{36}+\tfrac{1}{2}\dot{q}_6 c_{q3}\,s_{q4}\,s_{q5}\,p_{37}+\left(\dot{q}_1\left(2c_{q4}\,s_{q4}\,s_{q5}\,{c_{q3}}^2\,c_{q5}+2s_{q3}\,s_{q4}\,c_{q3}\,{c_{q5}}^2\right)-\right.$$
$$\left.\dot{q}_5\left(4s_{q3}\,{c_{q5}}^2+2c_{q3}\,c_{q4}\,s_{q5}\,c_{q5}-2s_{q3}\right)+\dot{q}_3\left(4c_{q3}\,s_{q5}\,{c_{q4}}^2\,c_{q5}-s_{q3}\,c_{q4}\,{c_{q5}}^2+s_{q3}\,c_{q4}\,c_{q5}-\right.\right.$$
$$\left.\left.4c_{q3}\,s_{q5}\,c_{q5}\right)-2c_{q3}\,{c_{q5}}^2\,\dot{q}_4\,s_{q4}\right)p_{40}+\left(\dot{q}_1\left(4s_{q5}\,{c_{q3}}^2\,{c_{q4}}^2-2s_{q5}\,{c_{q3}}^2+c_{q5}\,s_{q3}\,c_{q3}\,c_{q4}\right)-\right.$$
$$\left.\dot{q}_4 c_{q3}\,c_{q4}\,c_{q5}-2\dot{q}_3 c_{q3}\,c_{q4}\,s_{q4}\,s_{q5}\right)p_{41}+\dot{q}_1\left(c_{q3}{}^2-2{c_{q3}}^2\,{c_{q4}}^2\right)+2c_{q3}\,c_{q4}\,\dot{q}_3\,s_{q4}\,\big)p_{42}+$$
$$\left(c_{q3}\,c_{q4}\,\dot{q}_1\,s_{q3}-c_{q3}\,c_{q4}\,\dot{q}_4\right)p_{43}+\left(c_{q3}\,\dot{q}_1\,s_{q3}\,s_{q4}-c_{q3}\,\dot{q}_4\,s_{q4}\right)p_{48}$$

$$C_{15}=\left(\dot{q}_6\,s_{q3}\,s_{q4}\,s_{q5}\,s_{q6}-c_{q4}\,c_{q6}\,\dot{q}_4\,s_{q3}\,s_{q5}-c_{q5}\,c_{q6}\,\dot{q}_5\,s_{q3}\,s_{q4}-\tfrac{1}{2}\dot{q}_3\,c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}-\right.$$
$$\left.\dot{q}_1\left(c_{q3}\,c_{q5}\,c_{q6}-c_{q4}\,c_{q6}\,s_{q5}-c_{q3}\,c_{q5}\,s_{q3}\,s_{q6}+c_{q3}\,c_{q5}\,c_{q6}\,s_{q3}\right)\right)p_5+$$
$$\left(\dot{q}_1\left(2c_{q4}\,s_{q5}\,s_{q6}\,{c_{q3}}^2+2c_{q5}\,s_{q6}\,c_{q3}-c_{q4}\,s_{q5}\,s_{q6}\right)+\dot{q}_4\,c_{q4}\,s_{q3}\,s_{q5}\,s_{q6}\right.$$
$$\left.+\dot{q}_5\,c_{q5}\,s_{q3}\,s_{q4}\,s_{q6}+\dot{q}_6\,c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}\right)\big)p_6+\left(\dot{q}_1\left(c_{q4}\,c_{q5}\,{c_{q3}}^2-s_{q3}\,s_{q5}\,c_{q3}-2c_{q4}\,c_{q5}\right)+\right.$$
$$\left.\dot{q}_4\,c_{q4}\,c_{q5}\,s_{q3}-\dot{q}_5\,s_{q3}\,s_{q4}\,s_{q5}\right)p_7+\left(\dot{q}_1\left(\tfrac{1}{2}s_{q6}\,{c_{q3}}^2\,c_{q4}-s_{q6}\,{c_{q3}}^2\,{c_{q4}}^2\,{c_{q5}}^2-\right.\right.$$
$$\left.\tfrac{1}{2}c_{q6}\,s_{q4}\,{c_{q3}}^2\,c_{q4}\,c_{q5}-2s_{q6}\,{c_{q3}}^2\,{c_{q5}}^2+s_{q6}\,{c_{q3}}^2+4s_{q3}\,s_{q5}\,s_{q6}\,c_{q3}\,c_{q4}\,c_{q5}+\right.$$
$$\left.c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}\,c_{q3}+s_{q6}\,{c_{q5}}^2-\tfrac{1}{2}s_{q6}\right)-\dot{q}_3\left(c_{q3}\,{c_{q4}}^2\,c_{q5}\,c_{q6}-c_{q3}\,s_{q4}\,s_{q6}\,c_{q4}\,{c_{q5}}^2-\right.$$
$$\left.c_{q3}\,s_{q4}\,s_{q5}\,c_{q4}\,c_{q5}\,{c_{q6}}^2-s_{q3}\,s_{q5}\,c_{q4}\,c_{q6}+\tfrac{1}{2}c_{q3}\,s_{q4}\,s_{q6}\,c_{q4}+\tfrac{1}{2}c_{q3}\,c_{q5}\,c_{q6}+\right.$$
$$\left.s_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\,c_{q5}\right)+\dot{q}_5\left(2c_{q6}\,s_{q3}\,s_{q5}-c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\right)-\dot{q}_4\left(2s_{q3}\,s_{q6}\,{c_{q5}}^2+\right.$$
$$\left.2c_{q3}\,c_{q4}\,s_{q5}\,s_{q6}\,c_{q5}-s_{q3}\,s_{q6}+\tfrac{1}{2}c_{q3}\,c_{q6}\,s_{q4}\,s_{q5}\right)+\tfrac{1}{2}\dot{q}_6\,c_{q5}\,s_{q3}\,s_{q6}\big)p_{11}+$$
$$\left(\dot{q}_4\left(c_{q3}\,c_{q4}\,{c_{q5}}^2\,{c_{q6}}^2-\tfrac{1}{2}c_{q3}\,c_{q4}\,{c_{q6}}^2-c_{q5}\,{c_{q6}}^2\,s_{q3}\,s_{q5}-\tfrac{1}{2}c_{q3}\,c_{q5}\,{c_{q6}}^2\,s_{q4}\,s_{q5}\right)+\right.$$
$$\left.\dot{q}_3\left(c_{q3}\,s_{q5}\,s_{q6}\,{c_{q4}}^2\,c_{q6}-\tfrac{1}{2}s_{q3}\,s_{q5}\,c_{q4}\,c_{q5}\,{c_{q6}}^2+s_{q3}\,s_{q6}\,c_{q4}\,c_{q5}\,c_{q6}+s_{q3}\,s_{q4}\,{c_{q5}}^2\,{c_{q6}}^2-\right.\right.$$
$$\left.\left.\tfrac{1}{2}s_{q3}\,s_{q4}\,{c_{q6}}^2\right)-\dot{q}_6\left(\tfrac{1}{2}s_{q3}\,s_{q5}-{c_{q6}}^2\,s_{q3}\,s_{q5}-\tfrac{1}{2}c_{q3}\,c_{q4}\,c_{q5}+c_{q3}\,c_{q4}\,c_{q5}\,{c_{q6}}^2+\right.\right.$$
$$\left.\left.c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q5}\,s_{q6}\right)+\dot{q}_5\left(2c_{q3}\,c_{q4}\,{c_{q5}}^2\,{c_{q6}}^2+s_{q3}\,s_{q6}\,c_{q5}\,c_{q6}-c_{q3}\,c_{q4}\,{c_{q6}}^2+\right.\right.$$
$$\left.\left.c_{q3}\,c_{q4}\,s_{q5}\,s_{q6}\,c_{q6}\right)+\dot{q}_1\left(s_{q4}\,s_{q5}\,s_{q6}\,{c_{q3}}^2\,c_{q4}\,c_{q6}-s_{q5}\,{c_{q3}}^2\,c_{q5}\,{c_{q6}}^2-s_{q5}\,c_{q3}\,{c_{q4}}^2\,c_{q5}\,{c_{q6}}^2-\right.\right.$$
$$\left.\left.2s_{q3}\,c_{q3}\,c_{q4}\,{c_{q5}}^2\,{c_{q6}}^2+s_{q3}\,c_{q3}\,c_{q4}\,{c_{q6}}^2+s_{q3}\,s_{q4}\,s_{q6}\,c_{q3}\,c_{q5}\,c_{q6}+s_{q3}\,s_{q5}\,c_{q4}\,c_{q6}+\right.\right.$$
$$\left.\left.s_{q5}\,c_{q5}\,{c_{q6}}^2\right)\right)p_{12}+\left(-\dot{q}_1\left(s_{q5}\,{c_{q3}}^2\,{c_{q4}}^2\,c_{q5}+s_{q5}\,{c_{q3}}^2\,c_{q5}+s_{q3}\,c_{q3}\,c_{q4}\,{c_{q5}}^2-\tfrac{1}{2}s_{q3}\,c_{q3}\,c_{q4}-\right.\right.$$
$$\left.\left.\tfrac{1}{2}s_{2q_5}\right)-\dot{q}_4\left(-c_{q3}\,c_{q4}\,{c_{q5}}^2+s_{q3}\,s_{q5}\,c_{q5}+\tfrac{1}{2}c_{q3}\,c_{q4}\right)+\dot{q}_3\left(s_{q3}\,s_{q4}\,{c_{q5}}^2+\right.\right.$$
$$\left.\left.c_{q3}\,c_{q4}\,s_{q4}\,s_{q5}\,c_{q5}-\tfrac{1}{2}s_{q3}\,s_{q4}\right)\right)p_{13}+\left(\dot{q}_3\left(2c_{q3}\,s_{q5}\,{c_{q4}}^2\,{c_{q6}}^2+s_{q3}\,c_{q4}\,c_{q5}\,{c_{q6}}^2+\right.\right.$$
$$\left.\left.\tfrac{1}{2}s_{q3}\,c_{q4}\,c_{q5}\,c_{q6}-2s_{q3}\,s_{q4}\,s_{q6}\,{c_{q5}}^2\,c_{q6}-\tfrac{1}{2}c_{q3}\,s_{q5}\,{c_{q6}}^2\right)+\dot{q}_1\left(2s_{q5}\,s_{q6}\,{c_{q3}}^2\,{c_{q4}}^2\,c_{q5}\,c_{q6}+\right.\right.$$
$$\left.\left.2s_{q4}\,s_{q5}\,{c_{q3}}^2\,c_{q4}\,{c_{q6}}^2+2s_{q5}\,s_{q6}\,{c_{q3}}^2\,c_{q5}\,c_{q6}+4s_{q3}\,s_{q6}\,c_{q3}\,c_{q4}\,{c_{q5}}^2\,c_{q6}-\right.\right.$$
$$\left.\left.2s_{q3}\,s_{q6}\,c_{q3}\,c_{q4}\,c_{q6}+2s_{q3}\,s_{q4}\,c_{q3}\,c_{q5}\,{c_{q6}}^2-2s_{q5}\,s_{q6}\,c_{q5}\,c_{q6}\right)+\dot{q}_5\left(c_{q5}\,{c_{q6}}^2\,s_{q3}+\right.\right.$$
$$\left.\left.2c_{q3}\,c_{q4}\,{c_{q6}}^2\,s_{q5}\right)-\dot{q}_4\left(4c_{q3}\,c_{q4}\,s_{q6}\,{c_{q5}}^2\,c_{q6}+c_{q3}\,s_{q4}\,c_{q5}\,{c_{q6}}^2-4s_{q3}\,s_{q5}\,s_{q6}\,c_{q5}\,c_{q6}-\right.\right.$$
$$\left.\left.3c_{q3}\,c_{q4}\,s_{q6}\,c_{q6}\right)-\dot{q}_6\left(c_{q3}\,s_{q4}-2c_{q3}\,{c_{q6}}^2\,s_{q4}+c_{q6}\,s_{q3}\,s_{q5}\,s_{q6}-2c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q6}\right)\big)p_{14}+$$

(B.78)

$$\left(\dot{q}_4\left(c_{q4}c_{q5}s_{q2}-c_{q6}s_{q3}+2c_{q5}^{\,2}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}\right)-\dot{q}_5\left(s_{q2}s_{q4}s_{q5}-s_{q3}s_{q5}s_{q6}+\right.\right.$$
$$c_{q3}c_{q4}c_{q5}s_{q6}\Big)-\dot{q}_1\left(s_{q6}c_{q3}^{\,2}c_{q4}^{\,2}c_{q6}^{\,2}-2s_{q6}c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}^{\,2}-2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}+\right.$$
$$c_{q3}^{\,2}c_{q4}^{\,2}c_{q6}+s_{q4}s_{q6}c_{q3}^{\,2}c_{q4}c_{q5}-2c_{q3}^{\,2}c_{q5}^{\,2}c_{q6}+c_{q3}^{\,2}c_{q6}+2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}c_{q6}-$$
$$s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}+2c_{q5}^{\,2}c_{q6}-c_{q6}\Big)+\dot{q}_3\left(c_{q4}s_{q3}s_{q5}s_{q6}-c_{q3}c_{q4}^{\,2}c_{q5}s_{q6}+c_{q3}c_{q4}c_{q6}s_{q4}+\right.$$
$$c_{q5}c_{q6}s_{q3}s_{q4}s_{q5}-2c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}s_{q4}\Big)+\tfrac{1}{2}\dot{q}_2\,c_{q2}\,c_{q5}\,s_{q4}\Big)p_{15}+\Big(\dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q6}s_{q5}-$$
$$\tfrac{1}{2}c_{q2}c_{q6}s_{q4}s_{q5}\Big)-\dot{q}_1\left(2c_{q3}c_{q5}c_{q6}s_{q2}-2c_{q4}c_{q6}s_{q2}s_{q3}s_{q5}\right)-\dot{q}_4\,c_{q4}c_{q6}\,s_{q2}s_{q5}-$$
$$\dot{q}_5c_{q5}c_{q6}s_{q2}s_{q4}+\dot{q}_6s_{q2}s_{q4}s_{q5}s_{q6}\Big)p_{16}+\Big(\dot{q}_1\left(c_{q3}c_{q5}s_{q2}s_{q6}-2c_{q4}s_{q2}s_{q3}s_{q5}s_{q6}\right)+$$
$$\dot{q}_2\,c_{q2}\,s_{q4}s_{q5}s_{q6}+c_{q4}\dot{q}_4s_{q2}s_{q5}s_{q6}+c_{q5}\dot{q}_5s_{q2}s_{q4}s_{q6}+c_{q6}\dot{q}_6s_{q2}s_{q4}s_{q5}\Big)p_{17}-$$
$$\left(\dot{q}_2\,c_{q2}\,c_{q5}\;s_{q4}-\dot{q}_1\,c_{q3}\,s_{q2}s_{q5}\right)p_{18}+\Big(-\dot{q}_1\left(c_{q5}c_{q6}c_{q3}^{\,2}-c_{q4}c_{q6}s_{q3}s_{q5}c_{q3}+c_{q4}s_{q3}s_{q5}s_{q6}+\right.$$
$$2c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}s_{q5}\Big)-c_{q3}c_{q4}c_{q6}\dot{q}_4s_{q5}-c_{q3}c_{q5}c_{q6}\dot{q}_5s_{q4}+\tfrac{1}{2}c_{q6}\,\dot{q}_3\,s_{q3}\,s_{q4}\,s_{q5}+$$
$$c_{q3}\dot{q}_6s_{q4}s_{q5}s_{q6}\Big)\Big)p_{21}+\Big(\dot{q}_1\left(c_{q3}^{\,2}c_{q5}s_{q6}-c_{q3}c_{q4}s_{q3}s_{q5}s_{q6}\right)+c_{q3}c_{q4}\dot{q}_4s_{q5}s_{q6}+$$
$$c_{q3}c_{q5}\dot{q}_5s_{q4}s_{q6}+c_{q3}c_{q6}\dot{q}_6s_{q4}s_{q5}\Big)p_{22}+\Big(\dot{q}_6s_{q4}s_{q5}s_{q6}-c_{q5}c_{q6}\dot{q}_5s_{q4}-c_{q4}c_{q6}\dot{q}_4s_{q5}\Big)p_{23}+$$
$$\left(\dot{q}_4c_{q4}\;s_{q5}s_{q6}+\dot{q}_5c_{q5}s_{q4}s_{q6}+\dot{q}_6c_{q6}\;s_{q4}s_{q5}\right)p_{24}+\Big(-\dot{q}_1\left(s_{q5}c_{q3}^{\,2}+c_{q4}c_{q5}s_{q3}c_{q3}\right)-$$
$$\dot{q}_5c_{q3}\;s_{q4}s_{q5}+\dot{q}_4c_{q3}c_{q4}c_{q5}\;\Big)p_{25}\left(\tfrac{3}{2}\dot{q}_4c_{q4}c_{q5}-\dot{q}_1\left(c_{q3}s_{q5}+c_{q4}c_{q5}s_{q3}\right)-\dot{q}_5s_{q4}s_{q5}\right)p_{32}+$$
$$\Big(\dot{q}_1\Big(c_{q3}^{\,2}c_{q4}s_{q4}s_{q5}-c_{q3}c_{q5}s_{q3}s_{q4}\Big)+\dot{q}_3\Big(c_{q3}s_{q5}c_{q4}^{\,2}+c_{q5}s_{q3}c_{q4}\Big)+$$
$$\dot{q}_5\Big(c_{q5}s_{q3}+c_{q3}c_{q4}s_{q5}\Big)\Big)p_{33}+\tfrac{1}{2}\Big(c_{q3}c_{q4}\dot{q}_4-\tfrac{1}{2}\dot{q}_3s_{q3}s_{q4}\;\Big)p_{36}+$$
$$\left(\dot{q}_6\left(\tfrac{1}{2}s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}\,c_{q4}\,c_{q5}\right)\right)p_{37}+\Big(\dot{q}_4\Big(2s_{q3}-4s_{q3}c_{q5}^{\,2}-2c_{q3}c_{q4}s_{q5}c_{q5}\Big)+$$
$$\Big(\dot{q}_3\Big(4c_{q3}c_{q4}s_{q4}c_{q5}^{\,2}-2c_{q3}c_{q4}s_{q4}-s_{q3}s_{q4}s_{q5}\Big)+\dot{q}_1\left(c_{q3}^{\,2}c_{q4}^{\,2}-2c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}^{\,2}-\right.$$
$$2c_{q3}^{\,2}c_{q5}^{\,2}+c_{q3}^{\,2}+4s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}+2c_{q5}^{\,2}-1)\Big)p_{40}+$$
$$\Big(-\dot{q}_1\Big(c_{q3}s_{q3}s_{q4}s_{q5}-2c_{q3}^{\,2}c_{q4}c_{q5}s_{q4}\Big)-\dot{q}_3\Big(c_{q4}s_{q3}s_{q5}-c_{q3}c_{q4}^{\,2}c_{q5}\Big)-\dot{q}_5\Big(s_{q3}s_{q5}-c_{q3}c_{q4}c_{q5}\Big)\Big)p_{41}$$

$$C_{16}=\Big(\dot{q}_1\left(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}+c_{q3}s_{q5}s_{q6}-c_{q3}^{\,2}c_{q6}s_{q4}+c_{q3}c_{q6}s_{q3}s_{q5}+c_{q3}s_{q3}s_{q5}s_{q6}\right)-$$
$$\dot{q}_4\left(\tfrac{1}{2}c_{q6}s_{q3}s_{q4}-\tfrac{1}{2}s_{q3}s_{q4}s_{q6}+c_{q4}c_{q5}s_{q3}s_{q6}\right)-\dot{q}_6\Big(c_{q4}s_{q3}s_{q6}+c_{q5}c_{q6}s_{q3}s_{q4}\Big)-$$
$$\dot{q}_3\,c_{q5}\,s_{q3}\,s_{q4}\,s_{q6}+\dot{q}_5s_{q3}s_{q4}s_{q5}s_{q6}\Big)p_5+\Big(\dot{q}_4\;\left(s_{q3}s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}s_{q3}\right)-$$
$$\dot{q}_6\left(c_{q4}c_{q6}s_{q3}-c_{q5}s_{q3}s_{q4}s_{q6}\right)+\dot{q}_1\left(2c_{q3}^{\,2}s_{q4}s_{q6}-2s_{q4}s_{q6}+c_{q4}c_{q5}c_{q6}+\right.$$
$$2c_{q3}c_{q6}s_{q5}-2c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}\Big)+\dot{q}_5\,c_{q6}\,s_{q3}s_{q4}s_{q5}\Big)p_6+\Big(\dot{q}_1\left(\tfrac{1}{2}s_{q4}s_{q5}s_{q6}c_{q3}^{\,2}c_{q4}-\right.$$
$$\tfrac{1}{2}c_{q6}s_{q5}c_{q3}^{\,2}c_{q4}^{\,2}c_{q5}-c_{q6}s_{q5}c_{q3}^{\,2}c_{q5}-2c_{q6}s_{q3}c_{q3}c_{q4}c_{q5}^{\,2}+\tfrac{1}{2}c_{q6}s_{q3}c_{q3}c_{q4}+$$
$$s_{q3}s_{q4}s_{q6}c_{q3}c_{q5}+\tfrac{1}{2}c_{q6}s_{q5}c_{q5}\Big)+\Big(\dot{q}_3\Big(c_{q3}s_{q5}s_{q6}c_{q4}^{\,2}+c_{q3}c_{q6}s_{q4}s_{q6}c_{q4}c_{q5}^{\,2}+$$
$$\tfrac{1}{2}c_{q3}c_{q6}s_{q4}s_{q5}c_{q4}c_{q5}+\tfrac{1}{2}c_{q6}s_{q3}s_{q4}c_{q5}^{\,2}-c_{q6}s_{q3}s_{q4}-c_{q3}s_{q5}s_{q6}\Big)-$$
$$\dot{q}_6\Big(c_{q3}s_{q4}s_{q6}+c_{q6}s_{q3}s_{q5}-c_{q3}c_{q4}c_{q5}c_{q6}\Big)-\dot{q}_4\left(\tfrac{3}{2}3c_{q3}c_{q5}s_{q4}s_{q6}+c_{q5}c_{q6}s_{q3}s_{q5}-\right.$$
$$c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}\Big)+\tfrac{1}{2}\dot{q}_5\,c_{q5}\,s_{q3}s_{q6}\Big)p_{11}+\Big(\dot{q}_1\Big(-s_{q6}c_{q3}^{\,2}c_{q4}^{\,2}c_{q6}-$$
$$2s_{q4}c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}^{\,2}+s_{q4}c_{q3}^{\,2}c_{q4}c_{q5}-s_{q6}c_{q3}^{\,2}c_{q5}^{\,2}c_{q6}+2s_{q6}c_{q3}^{\,2}c_{q6}-$$
$$s_{q6}c_{q3}c_{q4}^{\,2}c_{q5}^{\,2}c_{q6}+2s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}c_{q5}c_{q6}+2s_{q3}s_{q4}s_{q5}c_{q3}c_{q6}^{\,2}-s_{q3}s_{q4}s_{q5}c_{q3}+$$
$$s_{q3}s_{q6}c_{q4}c_{q5}+s_{q6}c_{q5}^{\,2}c_{q6}-\tfrac{1}{2}s_{2q_6}\Big)-\dot{q}_5\left(\tfrac{1}{2}s_{q3}s_{q5}-c_{q6}^{\,2}s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}\,c_{q4}\,c_{q5}+\right.$$
$$c_{q3}c_{q4}c_{q5}c_{q6}^{\,2}+c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}s_{q6}\Big)-\dot{q}_4\Big(s_{q3}s_{q6}c_{q5}^{\,2}c_{q6}+c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6}+$$
$$c_{q3}s_{q4}s_{q5}c_{q6}^{\,2}-s_{q3}s_{q6}c_{q6}-\tfrac{1}{2}c_{q3}s_{q4}s_{q5}-\dot{q}_3\left(2c_{q3}c_{q5}c_{q4}^{\,2}c_{q6}^{\,2}-c_{q3}c_{q5}c_{q4}^{\,2}-\right.\tag{B.79}$$

$$s_{q3}\,s_{q5}\,c_{q4}\,c_{q6}^{\,2}-c_{q3}\,s_{q4}\,s_{q6}\,c_{q4}\,c_{q6}+\tfrac{1}{2}s_{q3}\,s_{q5}\,c_{q4}-c_{q3}\,c_{q5}\,c_{q6}^{\,2}+c_{q5}\,s_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\,c_{q6}+\tfrac{1}{2}c_{q3}\,c_{q5}\big)\big)p_{12}+\tfrac{1}{2}\dot{q}_4\,s_{2q_6}\,p_{13}+\big(\dot{q}_1\big(2c_{q3}^{\,2}\,c_{q4}^{\,2}\,c_{q5}^{\,2}\,c_{q6}^{\,2}+c_{q3}^{\,2}\,c_{q4}^{\,2}\,c_{q5}^{\,2}+4s_{q4}\,s_{q6}\,c_{q3}^{\,2}\,c_{q4}\,c_{q5}\,c_{q6}-2c_{q3}^{\,2}\,c_{q5}^{\,2}\,c_{q6}^{\,2}+c_{q3}^{\,2}\,c_{q5}^{\,2}+4c_{q3}^{\,2}\,c_{q6}^{\,2}-2c_{q3}^{\,2}+4s_{q3}\,s_{q5}\,c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}^{\,2}-2s_{q3}\,s_{q4}\,s_{q5}\,c_{q3}\,c_{q4}\,c_{q5}-4s_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\,c_{q3}\,c_{q6}+2c_{q5}^{\,2}\,c_{q6}^{\,2}+c_{q5}^{\,2}-2c_{q6}^{\,2}+1\big)+\dot{q}_4\big(2s_{q3}\,c_{q5}^{\,2}-4s_{q3}\,c_{q5}^{\,2}\,c_{q6}^{\,2}-4c_{q3}\,c_{q4}\,s_{q5}\,c_{q5}\,c_{q6}^{\,2}+2c_{q3}\,c_{q4}\,s_{q5}\,c_{q5}+4s_{q3}\,c_{q6}^{\,2}+4c_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\,c_{q6}-2s_{q3}\big)-\dot{q}_5\big(c_{q3}\,s_{q4}-2c_{q3}\,c_{q6}^{\,2}\,s_{q4}+c_{q6}\,s_{q3}\,s_{q5}\,s_{q6}-2c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q6}\big)-\dot{q}_3\big(\tfrac{3}{2}c_{q3}\,c_{q4}\,s_{q4}-c_{q5}\,s_{q3}\,s_{q4}\,s_{q5}+\tfrac{1}{2}c_{q4}\,s_{q3}\,s_{q5}\,s_{q6}-3c_{q3}\,c_{q4}\,c_{q6}^{\,2}\,s_{q4}+2c_{q3}\,c_{q5}\,c_{q6}\,s_{q6}-4c_{q3}\,c_{q4}^{\,2}\,c_{q5}\,c_{q6}\,s_{q6}+2c_{q5}\,c_{q6}^{\,2}\,s_{q3}\,s_{q4}\,s_{q5}\big)\big)p_{14}+\big(\dot{q}_1\big(3s_{q5}\,c_{q3}^{\,2}\,c_{q4}^{\,2}\,c_{q5}\,c_{q6}^{\,3}-2s_{q5}\,c_{q3}^{\,2}\,c_{q4}^{\,2}\,c_{q5}\,c_{q6}-s_{q5}\,s_{q6}\,c_{q3}^{\,2}\,c_{q4}^{\,2}\,c_{q5}-s_{q4}\,s_{q5}\,c_{q3}^{\,2}\,c_{q4}\,c_{q6}-s_{q5}\,s_{q6}\,c_{q3}^{\,2}\,c_{q5}-s_{q3}\,s_{q6}\,c_{q3}\,c_{q4}\,c_{q5}^{\,2}-s_{q3}\,s_{q4}\,c_{q3}\,c_{q5}\,c_{q6}+s_{q5}\,s_{q6}\,c_{q5}\big)+\dot{q}_4\big(\tfrac{1}{2}c_{q3}\,c_{q4}\,s_{q6}-c_{q5}\,s_{q3}\,s_{q5}\,s_{q6}+\tfrac{1}{2}c_{q3}\,c_{q4}\,c_{q5}^{\,2}\,s_{q6}+c_{q3}\,c_{q5}\,c_{q6}\,s_{q4}\big)+\dot{q}_6\big(c_{q3}\,c_{q6}\,s_{q4}-s_{q3}\,s_{q5}\,s_{q6}+c_{q3}\,c_{q4}\,c_{q5}\,s_{q6}\big)+\dot{q}_3\big(c_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\,c_{q4}\,c_{q5}-c_{q3}\,c_{q6}\,s_{q5}\,c_{q4}^{\,2}+\tfrac{1}{2}s_{q3}\,s_{q4}\,s_{q6}\,c_{q5}^{\,2}+c_{q3}\,c_{q6}\,s_{q5}\big)\big)p_{15}+\big(\dot{q}_2\big(c_{q2}\,c_{q5}\,s_{q6}-c_{q2}\,c_{q5}\,s_{q4}\,s_{q6}\big)-\dot{q}_4\big(c_{q6}\,s_{q2}\,s_{q4}+c_{q4}\,c_{q5}\,s_{q2}\,s_{q6}\big)-\dot{q}_6\big(c_{q4}\,s_{q2}\,s_{q6}+c_{q5}\,c_{q6}\,s_{q2}\,s_{q4}\big)+\dot{q}_1\big(c_{q6}\,s_{q2}\,s_{q3}\,s_{q4}+2c_{q3}\,s_{q2}\,s_{q5}\,s_{q6}+2c_{q4}\,c_{q5}\,s_{q2}\,s_{q3}\,s_{q6}\big)+\dot{q}_5\,s_{q2}\,s_{q4}\,s_{q5}\,s_{q6}\big)p_{16}+\big(\dot{q}_1\big(c_{q3}\,c_{q6}\,s_{q2}\,s_{q5}-2s_{q2}\,s_{q4}\,s_{q6}+2c_{q4}\,c_{q5}\,c_{q6}\,s_{q2}\,s_{q3}\big)+\dot{q}_4\big(s_{q2}\,s_{q4}\,s_{q6}-c_{q4}\,c_{q5}\,c_{q6}\,s_{q2}\big)-\dot{q}_6\big(c_{q4}\,c_{q6}\,s_{q2}-c_{q5}\,s_{q2}\,s_{q4}\,s_{q6}\big)-\dot{q}_2\,c_{q2}\,c_{q5}\,c_{q6}\,s_{q4}+\dot{q}_5\,c_{q6}\,s_{q2}\,s_{q4}\,s_{q5}\big)p_{17}+\big(\dot{q}_1\big(s_{q5}\,s_{q6}\,c_{q3}^{\,2}+c_{q4}\,s_{q3}\,s_{q6}\,c_{q3}\,c_{q5}+c_{q6}\,s_{q3}\,s_{q4}\,c_{q3}-c_{q4}\,s_{q2}\,s_{q3}\,s_{q6}\,c_{q5}^{\,2}+c_{q4}\,c_{q6}\,s_{q3}\,c_{q5}+c_{q4}\,s_{q2}\,s_{q3}\,s_{q6}\big)-\dot{q}_4\big(c_{q3}\,c_{q6}\,s_{q4}+c_{q3}\,c_{q4}\,c_{q5}\,s_{q6}\big)-\dot{q}_6\big(c_{q3}\,c_{q4}\,s_{q6}+c_{q3}\,c_{q5}\,c_{q6}\,s_{q4}\big)+\dot{q}_3\,c_{q5}\;s_{q3}\,s_{q4}\,s_{q6}+\dot{q}_5\,c_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\big)p_{21}+\big(\dot{q}_1\big(c_{q3}^{\,2}\,c_{q6}\,s_{q5}-c_{q3}\,s_{q3}\,s_{q4}\,s_{q6}+c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q3}\big)+\dot{q}_4\big(c_{q3}\,s_{q4}\,s_{q6}-c_{q3}\,c_{q4}\,c_{q5}\,c_{q6}\big)-\dot{q}_6\big(c_{q3}\,c_{q4}\,c_{q6}-c_{q3}\,c_{q5}\,s_{q4}\,s_{q6}\big)+\dot{q}_5\,c_{q3}\,c_{q6}\;s_{q4}\,s_{q5}\big)p_{22}+\big(c_{q6}\,\dot{q}_1\,s_{q3}\,s_{q4}-\dot{q}_6\big(c_{q4}\,s_{q6}+c_{q5}\,c_{q6}\,s_{q4}\big)-\dot{q}_4\big(c_{q6}\,s_{q4}+c_{q4}\,c_{q5}\,s_{q6}\big)+\dot{q}_5\,s_{q4}\,s_{q5}\,s_{q6}\big)p_{23}+\big(\dot{q}_4\big(\tfrac{1}{2}c_{q4}\,c_{q6}+\tfrac{1}{2}s_{q4}\,s_{q6}-c_{q4}\,c_{q5}\,c_{q6}\big)-\dot{q}_6\big(c_{q4}\,c_{q6}-c_{q5}\,s_{q4}\,s_{q6}\big)+c_{q6}\,\dot{q}_5\,s_{q4}\,s_{q5}-\dot{q}_1\,s_{q3}\,s_{q4}\,s_{q6}\big)p_{24}+\dot{q}_5\big(\tfrac{1}{2}s_{q3}\,s_{q5}-\tfrac{1}{2}c_{q3}\,c_{q4}\,c_{q5}\big)-\dot{q}_3\big(\tfrac{1}{2}c_{q3}\,c_{q5}-c_{q4}\,s_{q3}\,s_{q5}\big)+\tfrac{1}{2}\dot{q}_4\,c_{q3}\;s_{q4}\,s_{q5}\big)p_{37}$$

$$C_{21}=\tfrac{1}{2}\dot{q}_1\,s_{2q_2}\,p_1-\big(\tfrac{1}{2}\dot{q}_4\,c_{q2}\,c_{q4}\,s_{q5}+\tfrac{1}{2}\dot{q}_5\,c_{q2}\,c_{q5}\,s_{q4}\big)p_{15}+\big(\dot{q}_6\big(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q6}-c_{q2}\,c_{q4}\,c_{q6}+\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q4}\,s_{q6}\big)+\dot{q}_1\big(2c_{q2}\,c_{q3}\,c_{q6}\,s_{q5}-c_{q2}\,s_{q3}\,s_{q4}\,s_{q6}+2c_{q2}\,c_{q4}\,c_{q5}\,c_{q6}\,s_{q3}\big)+\dot{q}_4\big(c_{q2}\,s_{q4}\,s_{q6}-\tfrac{1}{2}c_{q2}\,c_{q4}\,c_{q5}\,c_{q6}\big)+\dot{q}_5\big(\tfrac{1}{2}c_{q2}\,c_{q6}\,s_{q5}+\tfrac{1}{2}c_{q2}\,c_{q6}\,s_{q4}\,s_{q5}\big)\big)p_{16}+\big(\dot{q}_4\,c_{q2}\,c_{q6}\;s_{q4}-\dot{q}_1\big(2c_{q2}\,c_{q6}\,s_{q4}+c_{q2}\,c_{q3}\,s_{q5}\,s_{q6}+2c_{q2}\,c_{q4}\,c_{q5}\,s_{q3}\,s_{q6}\big)+\dot{q}_6\,c_{q2}\,c_{q4}\;s_{q6}\big)p_{17}-\big(\tfrac{1}{2}\dot{q}_4\,c_{q2}\,c_{q4}\,s_{q5}+\tfrac{1}{2}\dot{q}_5\,c_{q2}\,c_{q5}\;s_{q4}+\dot{q}_1\,c_{q2}\,c_{q3}\,c_{q5}\big)p_{18}-\dot{q}_1\,c_{q2}\,s_{q3}\,p_{19}-c_{q2}\,c_{q3}\,\dot{q}_1\,p_{20}+\dot{q}_1\big(c_{q2}\,c_{q4}\,c_{q6}\,s_{q3}-c_{q2}\,c_{q4}\,c_{q5}^{\,2}\,c_{q6}\,s_{q3}\big)p_{21}+\dot{q}_1\,s_{q2}\,p_{24}-\tfrac{1}{2}c_{q2}\,\dot{q}_1\,p_{28}+\dot{q}_1\big(2c_{q2}^{\,2}-1\big)p_{49}\tag{B.80}$$

$$C_{22}=0\tag{B.81}$$

$$
\begin{aligned}
C_{23} = {} & \left(\dot{q}_5\left(\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q5} + \mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\right) + \right. \\
& \dot{q}_4\left(\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q4} + \mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\right) + \\
& \dot{q}_3\left(\mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} + \mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q5} + \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3} - \right. \\
& \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\left.\right) + \dot{q}_6\left(\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q4} + \right. \\
& \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q6} + \mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6}\left.\right)\right)p_{16} + \left(\dot{q}_3\left(\mathrm{C}_{q3}\,\mathrm{C}_{q5} - \right.\right. \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} + \mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4} - \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} - \mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} - \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6}\left.\right) + \\
& \dot{q}_4\left(\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6} - \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \tfrac{1}{2}\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6}\left.\right) - \right. \\
& \dot{q}_6\left(\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} - \mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5} + \mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6} - \right. \\
& \tfrac{1}{2}\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\left.\right) - \dot{q}_5\left(\tfrac{1}{2}\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \right. \\
& \tfrac{1}{2}\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6}\left.\right)\right)p_{17} + \left(-\dot{q}_3\left(\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5} + \mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} + \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\left.\right) + \right. \\
& \dot{q}_4\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} + \tfrac{1}{2}\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\right) - \dot{q}_5\left(\mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5} - \mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} - \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \right. \\
& \mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} + \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\left.\right)\right)p_{18} - \dot{q}_3\left(\mathrm{C}_{q2}\,\mathrm{S}_{q3} - \mathrm{C}_{q3}\,\mathrm{S}_{q2}\right)p_{19} - \dot{q}_3\left(\mathrm{C}_{q2}\,\mathrm{C}_{q3} + \mathrm{S}_{q2}\,\mathrm{S}_{q3}\right)p_{20} + \\
& \dot{q}_4\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5} + \tfrac{1}{2}\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\right)p_{38}
\end{aligned}
\tag{B.82}
$$

$$
\begin{aligned}
C_{24} = {} & \left(-\tfrac{1}{2}\dot{q}_1\,\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q5}\right)p_{15} + \left(\dot{q}_3\left(\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q4} + \right.\right. \\
& \mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\left.\right) - \dot{q}_4\left(\mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3} + \right. \\
& \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\left.\right) - \dot{q}_5\left(\mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5} - \mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\right) - \dot{q}_6\left(\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2} - \right. \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3} + \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} + \mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6}\left.\right) + \\
& \dot{q}_1\left(\mathrm{C}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\right)\left.\right)p_{16} + \left(\dot{q}_3\left(\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6} - \right.\right. \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6} - \tfrac{1}{2}\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q6}\left.\right) - \dot{q}_4\left(\mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4} + \right. \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q6}\left.\right) - \dot{q}_6\left(\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q6} + \right. \\
& \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\left.\right) + \dot{q}_5\left(\mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6}\right) + \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\dot{q}_1\,\mathrm{S}_{q4}\left.\right)p_{17} + \left(\dot{q}_5\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\right) + \dot{q}_3\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} + \right.\right. \\
& \tfrac{1}{2}\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\left.\right) - \tfrac{1}{2}\dot{q}_1\,\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q5}\left.\right)p_{18} + \left(\dot{q}_4\left(\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} - \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5}\right) + \right. \\
& \left.\left(\dot{q}_5\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \tfrac{1}{2}\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\right) + \dot{q}_3\left(\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5} + \tfrac{1}{2}\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\right)\right)p_{38}
\end{aligned}
\tag{B.83}
$$

$$
\begin{aligned}
C_{25} = {} & \left(-\tfrac{1}{2}\dot{q}_1\,\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q4}\right)p_{15} + \left(\dot{q}_3\left(\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q5} + \right.\right. \\
& \mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\left.\right) + \dot{q}_5\left(\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q5} + \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3} - \right. \\
& \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\left.\right) - \dot{q}_4\left(\mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5} - \mathrm{C}_{q3}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\right) + \dot{q}_6\left(\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} + \right. \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q6} - \sigma_2 - \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6}\left.\right) + \dot{q}_1\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q5} + \right. \\
& \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q6}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\left.\right)\left.\right)p_{16} + \left(\dot{q}_6\left(\mathrm{C}_{q5}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{C}_{q6} - \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \right.\right. \\
& \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q6}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5}\left.\right) - \dot{q}_5\left(\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} - \right. \\
& \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q6}\left.\right) + \dot{q}_4\left(\mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6}\right) - \dot{q}_3\left(\tfrac{1}{2}\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \right. \\
& \mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q6} - \mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q6} + \mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6} + \tfrac{1}{2}\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5}\,\mathrm{S}_{q6}\left.\right)\left.\right)p_{17} + \\
& \left(\dot{q}_4\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \tfrac{1}{2}\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\right) - \dot{q}_5\left(\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q5} + \mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} - \mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \right. \\
& \mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5}\left.\right) - \dot{q}_3\left(\mathrm{C}_{q3}\,\mathrm{S}_{q2}\,\mathrm{S}_{q5} - \mathrm{C}_{q2}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} - \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q4}\,\mathrm{S}_{q3}\,\mathrm{S}_{q5} + \mathrm{C}_{q4}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q3} + \right. \\
& \tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q3}\,\mathrm{C}_{q4}\,\mathrm{C}_{q5}\left.\right) - \tfrac{1}{2}\dot{q}_1\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q4}\left.\right)p_{18} + \left(\dot{q}_4\left(\tfrac{1}{2}\mathrm{C}_{q2}\,\mathrm{C}_{q5}\,\mathrm{S}_{q3}\,\mathrm{S}_{q4} - \tfrac{1}{2}\mathrm{C}_{q3}\,\mathrm{C}_{q5}\,\mathrm{S}_{q2}\,\mathrm{S}_{q4}\right)\right)p_{38}
\end{aligned}
\tag{B.84}
$$

$$
\begin{aligned}
C_{26} = &\Big(\dot{q}_1\Big(\tfrac{1}{2}c_{q2}c_{q5}s_{q6} - c_{q2}c_{q4}c_{q6} + \tfrac{1}{2}c_{q2}c_{q5}s_{q4}s_{q6}\Big) - \dot{q}_4\Big(c_{q3}c_{q4}c_{q6}s_{q2} - \\
&c_{q2}c_{q4}c_{q6}s_{q3} + \tfrac{1}{2}c_{q2}c_{q5}c_{q6}s_{q3}s_{q4} + c_{q2}c_{q5}s_{q3}s_{q4}s_{q6} - c_{q3}c_{q5}s_{q2}s_{q4}s_{q6}\Big) + \\
&\dot{q}_3\Big(c_{q6}s_{q2}s_{q3}s_{q4} - c_{q2}s_{q3}s_{q5}s_{q6} + c_{q3}s_{q2}s_{q5}s_{q6} + c_{q2}c_{q3}c_{q6}s_{q4} + \\
&\tfrac{1}{2}c_{q2}c_{q3}c_{q4}c_{q5}c_{q6} + c_{q2}c_{q3}c_{q4}c_{q5}s_{q6} + c_{q4}c_{q5}s_{q2}s_{q3}s_{q6}\Big) + \dot{q}_6\Big(c_{q3}s_{q2}s_{q4}s_{q6} - \\
&c_{q2}s_{q3}s_{q4}s_{q6} + c_{q6}s_{q2}s_{q3}s_{q5} + c_{q2}c_{q3}c_{q6}s_{q5} + c_{q2}c_{q4}c_{q5}c_{q6}s_{q3} - c_{q3}c_{q4}c_{q5}c_{q6}s_{q2} - \\
&c_{q2}c_{q4}c_{q5}s_{q3}s_{q6}\Big) + \dot{q}_5\Big(c_{q5}s_{q2}s_{q3}s_{q6} + c_{q2}c_{q3}c_{q5}s_{q6} - \tfrac{1}{2}c_{q2}c_{q4}c_{q6}s_{q3}s_{q5} - \\
&c_{q2}c_{q4}s_{q3}s_{q5}s_{q6} + c_{q3}c_{q4}s_{q2}s_{q5}s_{q6}\Big)\Big)p_{16} + \Big(\dot{q}_5\Big(c_{q5}c_{q6}s_{q2}s_{q3} + c_{q2}c_{q3}c_{q5}c_{q6} - \\
&\tfrac{1}{2}c_{q2}c_{q4}c_{q6}s_{q3}s_{q5} + c_{q3}c_{q4}c_{q6}s_{q2}s_{q5}\Big) - \dot{q}_4\Big(c_{q2}c_{q4}s_{q3}s_{q6} - c_{q3}c_{q4}s_{q2}s_{q6} + \\
&\tfrac{1}{2}c_{q2}c_{q5}c_{q6}s_{q3}s_{q4} - c_{q3}c_{q5}c_{q6}s_{q2}s_{q4}\Big) - \dot{q}_3\Big(c_{q2}c_{q3}s_{q4}s_{q6} + c_{q2}c_{q6}s_{q3}s_{q5} - \\
&c_{q3}c_{q6}s_{q2}s_{q5} + s_{q2}s_{q3}s_{q4}s_{q6} - \tfrac{1}{2}c_{q2}c_{q3}c_{q4}c_{q5}c_{q6} - \tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}\Big) - \\
&\dot{q}_6\Big(c_{q2}c_{q6}s_{q3}s_{q4} - c_{q3}c_{q6}s_{q2}s_{q4} + c_{q2}c_{q3}s_{q5}s_{q6} + s_{q2}s_{q3}s_{q5}s_{q6} - \\
&c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}\Big) + \dot{q}_1 c_{q2}c_{q4}s_{q6}\Big)p_{17}
\end{aligned}
\tag{B.85}
$$

$$
\begin{aligned}
C_{31} = &\Big(\dot{q}_1\Big(\tfrac{1}{2}s_{2q_3} - c_{q6}s_{q5} + s_{q5}s_{q6} - 2{c_{q3}}^2 s_{q5}s_{q6} - c_{q6}s_{q3}s_{q5} + 2{c_{q3}}^2 c_{q6}s_{q5} - \\
&2c_{q3}s_{q3}s_{q4}s_{q6}\Big) + \dot{q}_5\Big(c_{q3}c_{q6}s_{q4}s_{q5} - \tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5}\Big) + \dot{q}_4\Big(\tfrac{1}{2}c_{q3}c_{q6}s_{q4} + \\
&\tfrac{1}{2}c_{q3}s_{q4}s_{q6} - c_{q3}c_{q4}c_{q5}c_{q6} + \tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q3}\Big) - \dot{q}_6\Big(c_{q3}c_{q4}c_{q6} - c_{q3}c_{q5}s_{q4}s_{q6} + \\
&\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\Big)\Big)p_5 + \Big(\dot{q}_1\Big(2s_{q3}s_{q5}s_{q6} - 4c_{q3}c_{q6}s_{q3}s_{q4} - 4c_{q3}c_{q4}c_{q5}s_{q3}s_{q6}\Big) + \\
&\dot{q}_4\Big(c_{q3}c_{q6}s_{q4} + c_{q3}c_{q4}c_{q5}s_{q6}\Big) + \dot{q}_6\Big(c_{q3}c_{q4}s_{q6} + c_{q3}c_{q5}c_{q6}s_{q4}\Big) - \\
&\dot{q}_5 c_{q3}s_{q4}s_{q5}s_{q6}\Big)p_6 + \Big(\dot{q}_1\Big(2c_{q4}s_{q3}s_{q5}c_{q3} - 2c_{q5}{c_{q3}}^2 + c_{q5}\Big) - \dot{q}_4 c_{q3}c_{q4}s_{q5} - \\
&\dot{q}_5 c_{q3}c_{q5}s_{q4}\Big)p_7 + \Big(\dot{q}_6\Big(c_{q4}c_{q5}s_{q3}s_{q6} + c_{q3}{c_{q4}}^2 s_{q5}s_{q6} + \tfrac{1}{2}{c_{q5}}^2 c_{q6}s_{q3}s_{q4} + \\
&c_{q3}c_{q4}{c_{q5}}^2 c_{q6}s_{q4}s_{q6} + \tfrac{1}{2}c_{q3}c_{q4}c_{q5}c_{q6}s_{q4}s_{q5} + \dot{q}_5\Big(c_{q3}s_{q4}s_{q6}c_{q4}{c_{q5}}^2 - \\
&c_{q3}{c_{q4}}^2 c_{q5}c_{q6} + c_{q3}s_{q4}s_{q5}c_{q4}c_{q5}{c_{q6}}^2 - \tfrac{1}{2}c_{q3}s_{q4}s_{q6}c_{q4} + \tfrac{3}{2}c_{q3}c_{q5}c_{q6} - \\
&s_{q3}s_{q4}s_{q5}s_{q6}c_{q5}\Big) - \dot{q}_1\Big(s_{q6}{c_{q3}}^2 c_{q4} - 4s_{q6}{c_{q3}}^2 c_{q4}{c_{q5}}^2 - 2c_{q6}s_{q4}{c_{q3}}^2 c_{q5} + \\
&s_{q3}s_{q5}s_{q6}c_{q3}{c_{q4}}^2 c_{q5} + c_{q6}s_{q3}s_{q4}s_{q5}c_{q3}c_{q4} + 2s_{q3}s_{q5}s_{q6}c_{q3}c_{q5} + 2s_{q6}c_{q4}{c_{q5}}^2 - \\
&\tfrac{1}{2}s_{q6}c_{q4} + c_{q6}s_{q4}c_{q5}\Big) + \dot{q}_4\Big(c_{q3}s_{q5}s_{q6}{c_{q4}}^2 c_{q5} - c_{q3}{c_{q4}}^2{c_{q5}}^2{c_{q6}}^2 + \tfrac{3}{2}s_{q3}s_{q6}c_{q4}{c_{q5}}^2 + \\
&2c_{q3}s_{q4}s_{q5}c_{q4}c_{q6} - s_{q3}s_{q6}c_{q4} + \tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2 + \tfrac{3}{2}s_{q3}s_{q4}c_{q5}c_{q6} + \tfrac{1}{2}c_{q3}s_{q5}s_{q6}c_{q5}\Big)\Big)p_{11} + \\
&\Big(\dot{q}_6\Big(c_{q3}c_{q5}{c_{q4}}^2 - 2c_{q3}c_{q5}{c_{q4}}^2{c_{q6}}^2 + s_{q3}s_{q5}c_{q4}{c_{q6}}^2 + c_{q3}s_{q4}s_{q6}c_{q4}c_{q6} - \tfrac{1}{2}s_{q3}s_{q5}c_{q4} + \\
&c_{q3}c_{q5}{c_{q6}}^2 - c_{q5}s_{q3}s_{q4}s_{q5}s_{q6}c_{q6} - \tfrac{1}{2}c_{q3}c_{q5}\Big) + \dot{q}_1\Big(\tfrac{1}{2}{c_{q4}}^2{c_{q5}}^2{c_{q6}}^2 s_{q3} - 2c_{q3}{c_{q6}}^2 s_{q3} + \\
&c_{q6}s_{q4}s_{q5}s_{q6} - c_{q4}c_{q5}c_{q6}^2 s_{q5} + c_{q3}{c_{q4}}^2{c_{q6}}^2 s_{q3} + c_{q3}{c_{q5}}^2{c_{q6}}^2 s_{q3} + c_{q3}c_{q4}c_{q5}c_{q6} + \\
&2{c_{q3}}^2 c_{q4}c_{q5}{c_{q6}}^2 s_{q5} - 2{c_{q3}}^2 c_{q6}s_{q4}s_{q5}s_{q6} - 2c_{q3}c_{q4}c_{q5}c_{q6}s_{q3}s_{q4}s_{q6}\Big) + \\
&\dot{q}_4\Big(s_{q3}s_{q5}c_{q4}c_{q5}{c_{q6}}^2 - c_{q3}{c_{q4}}^2{c_{q6}}^2 + 2c_{q3}s_{q4}s_{q6}c_{q4}c_{q5}c_{q6} - \tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2 + \\
&c_{q3}c_{q6}^2 - s_{q3}s_{q4}s_{q5}s_{q6}c_{q6}\Big) + \dot{q}_5\Big(c_{q3}s_{q5}s_{q6}{c_{q4}}^2 c_{q6} + \tfrac{1}{2}s_{q3}s_{q5}c_{q4}c_{q5}{c_{q6}}^2 + \\
&s_{q3}s_{q4}{c_{q5}}^2{c_{q6}}^2 - \tfrac{1}{2}s_{q3}s_{q4}c_{q6}^2 - c_{q3}s_{q5}s_{q6}c_{q6}\Big)\Big)p_{12} + \Big(\dot{q}_4\Big(c_{q4}c_{q5}s_{q3}s_{q5} - \\
&c_{q3}{c_{q4}}^2{c_{q5}}^2\Big) + \dot{q}_1\Big(s_{q5}{c_{q3}}^2 c_{q4}c_{q5} + s_{q3}c_{q3}{c_{q4}}^2 c_{q5}^2 + s_{q3}c_{q3}{c_{q5}}^2 - \tfrac{1}{2}s_{q5}c_{q4}c_{q5}\Big) + \\
&\dot{q}_5\Big(s_{q3}s_{q4}{c_{q5}}^2 + c_{q3}c_{q4}s_{q4}s_{q5}c_{q5} - \tfrac{1}{2}s_{q3}s_{q4}\Big)\Big)p_{13} + \Big(\dot{q}_5\Big(2c_{q3}s_{q5}{c_{q4}}^2{c_{q6}}^2 - \\
&s_{q3}c_{q4}c_{q5}{c_{q6}}^2 + \tfrac{1}{2}s_{q3}c_{q4}c_{q5}c_{q6} - 2s_{q3}s_{q4}s_{q6}{c_{q5}}^2 c_{q6} - \tfrac{3}{2}c_{q3}s_{q5}{c_{q6}}^2 + 2s_{q3}s_{q4}s_{q6}c_{q6}\Big) - \\
&\dot{q}_1\Big(4s_{q5}s_{q6}{c_{q3}}^2 c_{q4}c_{q5}c_{q6} + 4s_{q4}s_{q5}c_{q3}^2 c_{q6}^2 + 2s_{q3}s_{q6}c_{q3}{c_{q4}}^2{c_{q5}}^2 c_{q6} +
\end{aligned}
\tag{B.86}
$$

$$
\begin{aligned}
&4s_{q3}s_{q4}c_{q3}c_{q4}c_{q5}c_{q6}^{\,2}+2s_{q3}s_{q6}c_{q3}c_{q5}^{\,2}c_{q6}-4s_{q3}s_{q6}c_{q3}c_{q6}-2s_{q5}s_{q6}c_{q4}c_{q5}c_{q6}\\
&-2s_{q4}s_{q5}c_{q6}^{\,2}\big)-\dot{q}_4\Big(\tfrac{7}{2}c_{q3}c_{q6}s_{q6}+\tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5}-\\
&3c_{q3}c_{q4}^{\,2}c_{q6}s_{q6}-2c_{q3}c_{q5}^{\,2}c_{q6}s_{q6}+2c_{q6}^{\,2}s_{q3}s_{q4}s_{q5}-4c_{q3}c_{q4}c_{q5}c_{q6}^{\,2}s_{q4}+\\
&3c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}s_{q6}\Big)-\dot{q}_6\Big(\tfrac{3}{2}c_{q3}c_{q4}s_{q4}-c_{q5}s_{q3}s_{q4}s_{q5}+\tfrac{1}{2}c_{q4}s_{q3}s_{q5}s_{q6}-\\
&3c_{q3}c_{q4}c_{q6}^{\,2}s_{q4}+2c_{q3}c_{q5}c_{q6}s_{q6}-4c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}s_{q6}+2c_{q5}c_{q6}^{\,2}s_{q3}s_{q4}s_{q5}\Big)\Big)p_{14}+\\
&\Big(\dot{q}_5\Big(c_{q3}c_{q5}s_{q6}-c_{q3}c_{q4}^{\,2}c_{q5}s_{q6}+c_{q3}c_{q4}c_{q6}s_{q4}+c_{q5}c_{q6}s_{q3}s_{q4}s_{q5}-2c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}s_{q4}\Big)+\\
&\dot{q}_1\Big(2s_{q4}s_{q6}c_{q3}^{\,2}c_{q5}-2c_{q3}^{\,2}c_{q4}c_{q5}^{\,2}c_{q6}+2s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}^{\,2}+2s_{q3}s_{q5}c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}-\\
&2s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}c_{q4}+2s_{q3}s_{q5}c_{q3}c_{q5}c_{q6}+c_{q4}c_{q5}^{\,2}c_{q6}-s_{q4}s_{q6}c_{q5}\Big)-\dot{q}_4\Big(\tfrac{1}{2}c_{q4}c_{q6}s_{q3}-\\
&c_{q5}s_{q3}s_{q4}s_{q6}+c_{q4}c_{q5}^{\,2}c_{q6}s_{q3}-2c_{q3}c_{q4}s_{q4}s_{q5}s_{q6}+2c_{q3}c_{q4}^{\,2}c_{q5}c_{q6}s_{q5}\Big)+\dot{q}_6\Big(s_{q3}s_{q4}s_{q6}-\\
&c_{q3}c_{q4}^{\,2}c_{q6}s_{q5}+\tfrac{1}{2}c_{q5}^{\,2}s_{q3}s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q5}s_{q4}s_{q5}s_{q6}\Big)\Big)p_{15}+\\
&\Big(\dot{q}_1\Big(2c_{q3}c_{q4}c_{q5}c_{q6}s_{q2}-c_{q3}s_{q2}s_{q4}s_{q6}-2c_{q6}s_{q2}s_{q3}s_{q5}\Big)\Big)p_{16}+\\
&\Big(\dot{q}_1\Big(s_{q2}s_{q3}s_{q5}s_{q6}-2c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}\Big)\Big)p_{17}+\dot{q}_1c_{q5}s_{q2}s_{q3}p_{18}-\dot{q}_1c_{q3}s_{q2}p_{19}+\dot{q}_1s_{q2}s_{q3}p_{20}+\\
&\Big(\dot{q}_1\Big(s_{q4}s_{q6}-2c_{q3}^{\,2}s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}-2c_{q3}c_{q6}s_{q3}s_{q5}+2c_{q3}^{\,2}c_{q4}c_{q5}c_{q6}+c_{q3}c_{q4}c_{q6}s_{q2}-\\
&c_{q3}c_{q4}c_{q5}s_{q6}-c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}s_{q2}\Big)-\dot{q}_4\Big(s_{q3}s_{q4}s_{q6}-\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q3}\Big)+\dot{q}_6\Big(c_{q4}c_{q6}s_{q3}-\\
&\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\Big)-\dot{q}_5c_{q6}s_{q3}s_{q4}s_{q5}\Big)p_{21}+\Big(\dot{q}_1\Big(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}-2c_{q3}^{\,2}c_{q6}s_{q4}+\\
&2c_{q3}s_{q3}s_{q5}s_{q6}-2c_{q3}^{\,2}c_{q4}c_{q5}s_{q6}\Big)-\dot{q}_4\Big(c_{q6}s_{q3}s_{q4}+c_{q4}c_{q5}s_{q3}s_{q6}\Big)-\dot{q}_6\Big(c_{q4}s_{q3}s_{q6}+\\
&c_{q5}c_{q6}s_{q3}s_{q4}\Big)+\dot{q}_5s_{q3}s_{q4}s_{q5}s_{q6}\Big)p_{22}-\dot{q}_1c_{q3}s_{q4}s_{q6}p_{23}-\dot{q}_1c_{q3}c_{q6}s_{q4}p_{24}+\\
&\Big(\dot{q}_1\Big(2c_{q4}s_{q5}c_{q3}^{\,2}+2c_{q5}s_{q3}c_{q3}-c_{q4}s_{q5}\Big)+\dot{q}_4c_{q4}s_{q3}s_{q5}+\dot{q}_5c_{q5}s_{q3}s_{q4}\Big)p_{25}-\\
&\dot{q}_1\Big(2c_{q3}^{\,2}-1\Big)p_{27}+\tfrac{1}{2}\dot{q}_1s_{q3}p_{29}+\tfrac{1}{2}\dot{q}_1s_{q3}p_{30}-\tfrac{1}{2}c_{q3}\dot{q}_1p_{31}+\dot{q}_1\Big(c_{q5}s_{q3}+c_{q3}c_{q4}s_{q5}\Big)p_{32}+\\
&\Big(-\dot{q}_5\Big(c_{q3}s_{q5}-c_{q3}c_{q4}^{\,2}s_{q5}\Big)-\dot{q}_4\Big(s_{q3}s_{q4}s_{q5}-2c_{q3}c_{q4}c_{q5}s_{q4}\Big)-\dot{q}_1\Big(2c_{q4}c_{q5}s_{q3}s_{q4}c_{q3}-\\
&2s_{q4}s_{q5}c_{q3}^{\,2}+s_{q4}s_{q5}\Big)\Big)p_{33}+\Big(-\dot{q}_4\Big(\tfrac{1}{2}c_{q3}-c_{q3}c_{q4}^{\,2}\Big)-\dot{q}_1c_{q3}c_{q4}^{\,2}s_{q3}\Big)p_{34}+\tfrac{1}{2}c_{q3}\dot{q}_4p_{35}+\\
&\tfrac{1}{2}\dot{q}_5s_{q3}s_{q4}p_{36}+\dot{q}_6\Big(\tfrac{1}{2}c_{q3}c_{q5}-\tfrac{1}{2}c_{q4}s_{q3}s_{q5}\Big)p_{37}+\Big(\dot{q}_4\Big(4c_{q3}s_{q5}c_{q4}^{\,2}c_{q5}+s_{q3}c_{q4}c_{q5}^{\,2}+\\
&s_{q3}c_{q4}c_{q5}\Big)-\dot{q}_1\Big(2s_{q3}s_{q5}c_{q3}c_{q4}^{\,2}c_{q5}-4c_{q3}^{\,2}c_{q4}c_{q5}^{\,2}+2s_{q3}s_{q5}c_{q3}c_{q5}+2c_{q4}c_{q5}^{\,2}\Big)-\\
&\dot{q}_5\Big(2c_{q3}c_{q4}s_{q4}-4c_{q3}c_{q4}s_{q4}c_{q5}^{\,2}+s_{q3}s_{q4}s_{q5}\Big)\Big)p_{40}+\Big(\dot{q}_5\Big(c_{q3}c_{q4}^{\,2}c_{q5}-c_{q3}c_{q5}\Big)+\\
&\dot{q}_1\Big(c_{q5}s_{q4}-2c_{q5}s_{q4}c_{q3}^{\,2}+4c_{q4}s_{q3}s_{q4}s_{q5}c_{q3}\Big)-\dot{q}_4\Big(c_{q5}s_{q3}s_{q4}+2c_{q3}c_{q4}s_{q4}s_{q5}\Big)\Big)p_{41}+\\
&\Big(2c_{q3}c_{q4}\dot{q}_4s_{q4}-2c_{q3}c_{q4}\dot{q}_1s_{q3}s_{q4}\Big)p_{42}+\Big(\dot{q}_1\Big(s_{q4}-2c_{q3}^{\,2}s_{q4}\Big)-\dot{q}_4s_{q3}s_{q4}\Big)p_{43}+\\
&\Big(c_{q4}\dot{q}_4s_{q3}-\dot{q}_1\Big(c_{q4}-2c_{q3}^{\,2}c_{q4}\Big)\Big)p_{48}
\end{aligned}
$$

$$
\begin{aligned}
C_{32}=&\Big(\dot{q}_2\Big(c_{q2}s_{q3}s_{q4}s_{q6}-c_{q3}s_{q2}s_{q4}s_{q6}-c_{q6}s_{q2}s_{q3}s_{q5}-c_{q2}c_{q3}c_{q6}s_{q5}-\\
&c_{q2}c_{q4}c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q5}c_{q6}s_{q2}\Big)-\dot{q}_6c_{q2}c_{q3}c_{q4}c_{q5}c_{q6}\Big)p_{16}+\\
&\Big(\dot{q}_6\Big(\tfrac{1}{2}c_{q2}c_{q3}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}\Big)-\dot{q}_5\Big(\tfrac{1}{2}s_{q3}s_{q5}-\tfrac{1}{2}c_{q4}s_{q2}s_{q3}s_{q5}s_{q6}\Big)+\\
&\dot{q}_2\Big(c_{q2}c_{q6}s_{q3}s_{q4}-c_{q3}c_{q6}s_{q2}s_{q4}+c_{q2}c_{q3}s_{q5}s_{q6}+s_{q2}s_{q3}s_{q5}s_{q6}-c_{q3}c_{q4}c_{q5}s_{q2}s_{q6}\Big)+\\
&\tfrac{1}{2}\dot{q}_4c_{q5}s_{q2}s_{q3}s_{q4}s_{q6}\Big)p_{17}+\Big(\dot{q}_5\Big(\tfrac{1}{2}c_{q2}c_{q4}s_{q3}s_{q5}+\tfrac{1}{2}c_{q2}c_{q3}c_{q4}c_{q5}\Big)+\\
&\dot{q}_4\Big(c_{q2}c_{q5}s_{q3}s_{q4}+\tfrac{1}{2}s_{q2}s_{q3}s_{q4}s_{q5}\Big)+\dot{q}_2\Big(c_{q2}c_{q3}c_{q5}+c_{q5}s_{q2}s_{q3}-c_{q2}c_{q4}s_{q3}s_{q5}+\\
&c_{q4}c_{q5}s_{q2}s_{q3}\Big)\Big)p_{18}+\dot{q}_2\Big(c_{q2}s_{q3}-c_{q3}s_{q2}\Big)p_{19}+\dot{q}_2\Big(c_{q2}c_{q3}+s_{q2}s_{q3}\Big)p_{20}-\\
&\dot{q}_4\Big(\tfrac{1}{2}c_{q2}c_{q3}s_{q4}s_{q5}+\tfrac{1}{2}s_{q2}s_{q3}s_{q4}s_{q5}\Big)p_{38}
\end{aligned}
\tag{B.87}
$$

$$
\begin{aligned}
C_{33} = {} & \left(\dot{q}_4\left(c_{q4}s_{q6}+c_{q5}c_{q6}s_{q4}\right)+\dot{q}_6\left(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}\right)+c_{q4}c_{q6}\dot{q}_5 s_{q5}\right)p_5 + \\
& \left(\dot{q}_4\left(c_{q4}c_{q6}-2c_{q5}s_{q4}s_{q6}\right)-\dot{q}_6\left(s_{q4}s_{q6}-2c_{q4}c_{q5}c_{q6}\right)-2\dot{q}_5\, c_{q4}s_{q5}s_{q6}\right)p_6 + \\
& \left(\dot{q}_4 s_{q4}s_{q5}-c_{q4}c_{q5}\dot{q}_5\right)p_7+\left(\dot{q}_5\left(2s_{q6}{c_{q4}}^2{c_{q5}}^2-s_{q6}{c_{q4}}^2+c_{q6}s_{q4}c_{q4}c_{q5}-\right.\right. \\
& \left.2s_{q6}{c_{q5}}^2+s_{q6}\right)-\dot{q}_6\left(s_{q4}s_{q5}s_{q6}c_{q4}-c_{q5}c_{q6}s_{q5}{c_{q4}}^2+c_{q5}c_{q6}s_{q5}\right)-\dot{q}_4\left(c_{q6}s_{q5}-\right. \\
& \left.\left.2c_{q6}s_{q5}{c_{q4}}^2+2c_{q5}s_{q4}s_{q5}s_{q6}c_{q4}\right)\right)p_{11}+\left(\dot{q}_5\left(c_{q5}s_{q5}{c_{q4}}^2{c_{q6}}^2-s_{q4}s_{q5}s_{q6}c_{q4}c_{q6}-\right.\right. \\
& \left.c_{q5}s_{q5}{c_{q6}}^2\right)+\dot{q}_4\left(2s_{q6}{c_{q4}}^2c_{q5}c_{q6}+s_{q4}c_{q4}{c_{q5}}^2{c_{q6}}^2+s_{q4}c_{q4}{c_{q6}}^2-s_{q6}c_{q5}c_{q6}-\right. \\
& \left.s_{2q_4}\right)+\dot{q}_6\left(s_{q6}{c_{q4}}^2{c_{q5}}^2c_{q6}+s_{q6}{c_{q4}}^2c_{q6}+2s_{q4}c_{q4}c_{q5}{c_{q6}}^2-s_{q4}c_{q4}c_{q5}-\right. \\
& \left.\left.s_{q6}{c_{q5}}^2c_{q6}\right)\right)p_{12}+c_{q4}{c_{q5}}^2\dot{q}_4 s_{q4}-\dot{q}_5\left(s_{2q_5}-{c_{q4}}^2c_{q5}s_{q5}\right)\Big)p_{13}+\left(\dot{q}_5\left(2c_{q5}s_{q5}s_{q6}c_{q6}-\right.\right. \\
& \left.s_{q5}s_{q6}{c_{q4}}^2c_{q6}-s_{q4}s_{q5}c_{q4}{c_{q6}}^2\right)-\dot{q}_4\left(c_{q5}{c_{q6}}^2-2{c_{q4}}^2c_{q5}{c_{q6}}^2+c_{q4}c_{q6}s_{q4}s_{q6}+\right. \\
& \left.c_{q4}c_{q5}c_{q6}s_{q4}s_{q6}\right)+\dot{q}_6\left({c_{q4}}^2c_{q5}{c_{q6}}^2-\tfrac{1}{2}{c_{q4}}^2c_{q5}+{c_{q4}}^2{c_{q6}}^2-2{c_{q5}}^2{c_{q6}}^2+{c_{q5}}^2-\right. \\
& \left.\left.2s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}{c_{q4}}^2\right)\right)p_{14}+\dot{q}_6\left(c_{q6}s_{q4}s_{q5}c_{q4}-c_{q5}s_{q5}s_{q6}{c_{q4}}^2-c_{q5}s_{q5}s_{q6}\right)+ \\
& \dot{q}_5\left(2c_{q6}{c_{q4}}^2{c_{q5}}^2-c_{q6}{c_{q4}}^2+s_{q4}s_{q6}c_{q4}c_{q5}+2c_{q6}{c_{q5}}^2-c_{q6}\right)+\dot{q}_4\left(2s_{q5}s_{q6}{c_{q4}}^2-\right. \\
& \left.2c_{q5}c_{q6}s_{q4}s_{q5}c_{q4}-s_{q5}s_{q6}\right)\Big)p_{15}+\left(\dot{q}_6 s_{q5}s_{q6}-c_{q5}c_{q6}\dot{q}_5\right)p_{21}+ \\
& \left(c_{q5}\dot{q}_5 s_{q6}+c_{q6}\dot{q}_6 s_{q5}\right)p_{22}-\dot{q}_5 s_{q5}\, p_{25}+\dot{q}_4\left(2{c_{q4}}^2c_{q5}-c_{q5}\right)+\dot{q}_5\, c_{q4}\, s_{q4}s_{q5}\Big)p_{33}+ \\
& \left(\dot{q}_5\left(2{c_{q4}}^2{c_{q5}}^2-{c_{q4}}^2-4{c_{q5}}^2+2\right)-2\dot{q}_4\, c_{q4}c_{q5}s_{q4}s_{q5}\right)p_{40}+ \\
& \left(\dot{q}_4\left(s_{q5}-2{c_{q4}}^2s_{q5}\right)-c_{q4}c_{q5}\dot{q}_5 s_{q4}\right)p_{41}+\left(\dot{q}_4\left(2{c_{q4}}^2-1\right)\right)p_{42}
\end{aligned}
\tag{B.88}
$$

$$
\begin{aligned}
C_{34} = {} & \left(\dot{q}_1\left(\tfrac{1}{2}c_{q3}c_{q6}s_{q4}+\tfrac{1}{2}c_{q3}s_{q4}s_{q6}-c_{q3}c_{q4}c_{q5}c_{q6}+\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q3}\right)+\right. \\
& \left.\dot{q}_3\left(c_{q4}s_{q6}+c_{q5}c_{q6}s_{q4}\right)\right)p_5+\left(\dot{q}_1\left(c_{q3}c_{q6}s_{q4}+c_{q3}c_{q4}c_{q5}s_{q6}\right)+\dot{q}_3\left(c_{q4}c_{q6}-\right.\right. \\
& \left.2c_{q5}s_{q4}s_{q6}\right)p_6+\left(\dot{q}_3 s_{q4}s_{q5}-c_{q3}c_{q4}\dot{q}_1 s_{q5}\right)p_7+\left(-\dot{q}_6\left(c_{q6}s_{q4}{c_{q5}}^2+c_{q4}s_{q6}c_{q5}\right)+\right. \\
& \dot{q}_3\left(2c_{q6}s_{q5}{c_{q4}}^2-2c_{q5}s_{q4}s_{q5}s_{q6}c_{q4}-c_{q6}s_{q5}\right)+\dot{q}_1\left(-c_{q3}{c_{q4}}^2{c_{q5}}^2{c_{q6}}^2+\right. \\
& c_{q3}s_{q5}s_{q6}{c_{q4}}^2c_{q5}+\tfrac{3}{2}s_{q3}s_{q6}c_{q4}{c_{q5}}^2+2c_{q3}s_{q4}s_{q5}c_{q4}c_{q6}-s_{q3}s_{q6}c_{q4}+ \\
& \tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2+\tfrac{3}{2}s_{q3}s_{q4}c_{q5}c_{q6}+\tfrac{1}{2}c_{q3}s_{q5}s_{q6}c_{q5}\Big)- \\
& \dot{q}_4\left(2c_{q4}s_{q6}{c_{q5}}^2+c_{q6}s_{q4}c_{q5}-c_{q4}s_{q6}\right)+2\dot{q}_5\, c_{q5}s_{q4}s_{q5}s_{q6}\Big)p_{11}+ \\
& \left(\dot{q}_1\left(s_{q3}s_{q5}c_{q4}c_{q5}{c_{q6}}^2-c_{q3}{c_{q4}}^2{c_{q6}}^2+2c_{q3}s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2+\right.\right. \\
& c_{q3}{c_{q6}}^2-s_{q3}s_{q4}s_{q5}s_{q6}c_{q6}\Big)+\dot{q}_3\left(2s_{q6}{c_{q4}}^2c_{q5}c_{q6}+s_{q4}c_{q4}{c_{q5}}^2{c_{q6}}^2+s_{q4}c_{q4}{c_{q6}}^2-\right. \\
& \left.s_{q6}c_{q5}c_{q6}-\tfrac{1}{2}s_{2q_4}\right)+\dot{q}_4\left(c_{q4}c_{q5}s_{q5}{c_{q6}}^2+s_{q4}s_{q5}s_{q6}c_{q6}\right)+\dot{q}_5\left(s_{q4}{c_{q5}}^2{c_{q6}}^2+\right. \\
& \left.\left.\tfrac{1}{2}s_{q4}{c_{q5}}^2-\tfrac{1}{2}s_{q4}{c_{q6}}^2\right)-\dot{q}_6\left(c_{q4}s_{q5}{c_{q6}}^2+c_{q5}s_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q4}s_{q5}\right)\Big)p_{12}+ \\
& \left(\dot{q}_5\left(\tfrac{1}{2}s_{q4}-{c_{q5}}^2s_{q4}\right)-\dot{q}_1\left(c_{q3}{c_{q4}}^2{c_{q5}}^2-c_{q4}c_{q5}s_{q3}s_{q5}\right)-\dot{q}_4\, c_{q4}c_{q5}s_{q5}+\right. \\
& \left.\dot{q}_3 c_{q4}{c_{q5}}^2s_{q4}\right)p_{13}+\left(\dot{q}_5\left({c_{q5}}^2c_{q6}s_{q4}s_{q6}-c_{q6}s_{q4}s_{q6}\right)+\dot{q}_6\left(c_{q5}s_{q4}s_{q5}{c_{q6}}^2+\right.\right. \\
& c_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q5}s_{q4}s_{q5}-\dot{q}_3\left(c_{q5}{c_{q6}}^2-2{c_{q4}}^2c_{q5}{c_{q6}}^2+c_{q4}c_{q6}s_{q4}s_{q6}+\right. \\
& \left.c_{q4}c_{q5}c_{q6}s_{q4}s_{q6}\right)+\dot{q}_4\left(s_{q4}s_{q5}{c_{q6}}^2+c_{q4}c_{q5}s_{q5}s_{q6}c_{q6}\right)-\dot{q}_1\left(\tfrac{7}{2}c_{q3}c_{q6}s_{q6}+\right. \\
& \tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5}-3c_{q3}{c_{q4}}^2c_{q6}s_{q6}-2c_{q3}{c_{q5}}^2c_{q6}s_{q6}+2{c_{q6}}^2s_{q3}s_{q4}s_{q5}- \\
& \left.\left.4c_{q3}c_{q4}c_{q5}{c_{q6}}^2s_{q4}+3c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}s_{q6}\right)\right)p_{14}+\left(\dot{q}_6\left(c_{q4}c_{q5}c_{q6}-\right.\right. \\
& \left.\tfrac{1}{2}{c_{q5}}^2s_{q4}s_{q6}-2c_{q3}c_{q5}c_{q6}s_{q3}s_{q5}\right)-\dot{q}_1\left(\tfrac{1}{2}c_{q4}c_{q6}s_{q3}-c_{q5}s_{q3}s_{q4}s_{q6}+\right.
\end{aligned}
\tag{B.89}
$$

$$
\begin{aligned}
&c_{q4}\,c_{q5}{}^2\,c_{q6}\,s_{q3}-2c_{q3}\,c_{q4}\,s_{q4}\,s_{q5}\,s_{q6}+2c_{q3}\,c_{q4}{}^2\,c_{q5}\,c_{q6}\,s_{q5}\big)-\\
&\dot{q}_4\big(s_{q4}\,s_{q6}\,c_{q5}-c_{q4}\,c_{q6}\,c_{q5}{}^2+c_{q4}\,c_{q6}\big)-\dot{q}_3\big(2c_{q5}\,c_{q6}\,s_{q4}\,s_{q5}\,c_{q4}-2s_{q5}\,s_{q6}\,c_{q4}{}^2+s_{q5}\,s_{q6}\big)-\\
&\dot{q}_5\,c_{q5}\,c_{q6}\,s_{q4}\,s_{q5}\big)p_{15}++\tfrac{1}{2}c_{q5}\,\dot{q}_2\,s_{q2}\,s_{q3}\,s_{q4}\,s_{q6}\,p_{17}+\dot{q}_2\big(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q3}\,s_{q4}+\tfrac{1}{2}s_{q2}\,s_{q3}\,s_{q4}\,s_{q5}\big)p_{18}+\\
&\big(\dot{q}_4\big(s_{q4}\,s_{q6}-c_{q4}\,c_{q5}\,c_{q6}\big)-\dot{q}_1\big(s_{q3}\,s_{q4}\,s_{q6}-\tfrac{1}{2}c_{q4}\,c_{q5}\,c_{q6}\,s_{q3}\big)-\dot{q}_6\big(c_{q4}\,c_{q6}-c_{q5}\,s_{q4}\,s_{q6}\big)+\\
&\dot{q}_5\,c_{q6}\,s_{q4}\,s_{q5}\big)p_{21}+\big(\dot{q}_4\,\big(c_{q6}\,s_{q4}+c_{q4}\,c_{q5}\,s_{q6}\big)-\dot{q}_1\big(c_{q6}\,s_{q3}\,s_{q4}+c_{q4}\,c_{q5}\,s_{q3}\,s_{q6}\big)+\dot{q}_6\,c_{q4}\,s_{q6}-\\
&\dot{q}_5\,s_{q4}\,s_{q5}\,s_{q6}\big)p_{22}+\big(c_{q4}\,\dot{q}_1\,s_{q3}\,s_{q5}-c_{q5}\,\dot{q}_5\,s_{q4}-c_{q4}\,\dot{q}_4\,s_{q5}\big)p_{25}+\dot{q}_4\,s_{q4}\,s_{q5}-\dot{q}_1\big(s_{q3}\,s_{q4}\,s_{q5}-\\
&2c_{q3}\,c_{q4}\,c_{q5}\,s_{q4}\big)-\dot{q}_3\Big(c_{q5}-2c_{q4}{}^2\,c_{q5}\Big)\Big)p_{33}-\dot{q}_1\Big(\tfrac{1}{2}c_{q3}-c_{q3}\,c_{q4}{}^2\Big)p_{34}+\tfrac{1}{2}c_{q3}\,\dot{q}_1\,p_{35}-\tfrac{1}{2}\dot{q}_5\,s_{q4}\,p_{36}\\
&+\tfrac{1}{2}\dot{q}_6\,c_{q4}\,s_{q5}\,p_{37}+\big(-\dot{q}_2\big(\tfrac{1}{2}c_{q2}\,c_{q3}\,s_{q4}\,s_{q5}+\tfrac{1}{2}s_{q2}\,s_{q3}\,s_{q4}\,s_{q5}\big)p_{38}+\big(\dot{q}_1\big(4c_{q3}\,s_{q5}\,c_{q4}{}^2\,c_{q5}+\\
&s_{q3}\,c_{q4}\,c_{q5}{}^2+s_{q3}\,c_{q4}\,c_{q5}\big)-2\dot{q}_4\,c_{q4}\,c_{q5}{}^2+2\dot{q}_5\,c_{q5}\,s_{q4}\,s_{q5}-2\dot{q}_3\,c_{q4}\,c_{q5}\,s_{q4}\,s_{q5}\big)p_{40}+\\
&\big(\dot{q}_3\,\big(s_{q5}-2c_{q4}{}^2\,s_{q5}\big)-\dot{q}_1\big(c_{q5}\,s_{q3}\,s_{q4}+2c_{q3}\,c_{q4}\,s_{q4}\,s_{q5}\big)+c_{q5}\,\dot{q}_4\,s_{q4}\big)p_{41}+\big(\dot{q}_3\,\big(2c_{q4}{}^2-1\big)+\\
&2\dot{q}_1\,c_{q3}\,c_{q4}\,s_{q4}\big)p_{42}+\big(\dot{q}_4\,s_{q4}-\dot{q}_1\,s_{q3}\,s_{q4}\big)p_{43}+\big(c_{q4}\,\dot{q}_1\,s_{q3}-c_{q4}\,\dot{q}_4\big)p_{48}
\end{aligned}
$$

$$
\begin{aligned}
C_{35}=\;&\dot{q}_1\big(c_{q3}\,c_{q6}\,s_{q4}\,s_{q5}-\tfrac{1}{2}c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}\big)+\dot{q}_5\,c_{q6}\,s_{q5}+\dot{q}_6\,c_{q5}\,s_{q6}+\dot{q}_3\,c_{q4}\,c_{q6}\,s_{q5}\big)p_5+\\
&\big(\dot{q}_6\,c_{q5}\,c_{q6}-\dot{q}_5\,s_{q5}\,s_{q6}-2\dot{q}_3\,c_{q4}\,s_{q5}\,s_{q6}-\dot{q}_1\,c_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\big)p_6-\big(\dot{q}_5\,c_{q5}+\dot{q}_3\,c_{q4}\,c_{q5}+\\
&\dot{q}_1\,c_{q3}\,c_{q5}\,s_{q4}\big)p_7+\big(\dot{q}_3\Big(2s_{q6}\,c_{q4}{}^2\,c_{q5}{}^2-s_{q6}\,c_{q4}{}^2+c_{q6}\,s_{q4}\,c_{q4}\,c_{q5}-2s_{q6}\,c_{q5}{}^2+s_{q6}\Big)+\\
&\dot{q}_1\big(c_{q3}\,s_{q4}\,s_{q5}\,c_{q4}\,c_{q5}\,c_{q6}{}^2-c_{q3}\,c_{q4}{}^2\,c_{q5}\,c_{q6}+c_{q3}\,s_{q4}\,s_{q6}\,c_{q4}\,c_{q5}{}^2-\tfrac{1}{2}c_{q3}\,s_{q4}\,s_{q6}\,c_{q4}+\\
&\tfrac{1}{2}3c_{q3}\,c_{q5}\,c_{q6}-s_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\,c_{q5}\big)+\dot{q}_5\,c_{q5}\,c_{q6}\,s_{q4}+2\dot{q}_4\,c_{q5}\,s_{q4}\,s_{q5}\,s_{q6}\big)p_{11}+\\
&\big(\dot{q}_6\Big(c_{q5}\,c_{q6}{}^2\,s_{q4}-c_{q5}\,s_{q4}\Big)-\dot{q}_3\Big(c_{q5}\,s_{q5}\,c_{q6}{}^2-c_{q5}\,s_{q5}\,c_{q4}{}^2\,c_{q6}{}^2+s_{q4}\,s_{q5}\,s_{q6}\,c_{q4}\,c_{q6}\Big)+\\
&\dot{q}_1\big(c_{q3}\,s_{q5}\,s_{q6}\,c_{q4}{}^2\,c_{q6}+\tfrac{1}{2}s_{q3}\,s_{q5}\,c_{q4}\,c_{q5}\,c_{q6}{}^2+s_{q3}\,s_{q4}\,c_{q5}{}^2\,c_{q6}{}^2-\tfrac{1}{2}s_{q3}\,s_{q4}\,c_{q6}{}^2-\\
&c_{q3}\,s_{q5}\,s_{q6}\,c_{q6}\big)+\dot{q}_4\Big(s_{q4}\,c_{q5}{}^2\,c_{q6}{}^2+\tfrac{1}{2}s_{q4}\,c_{q5}{}^2-\tfrac{1}{2}s_{q4}\,c_{q6}{}^2\Big)+\dot{q}_5\big(2c_{q4}\,c_{q5}\,s_{q5}-\\
&c_{q6}\,s_{q4}\,s_{q5}\,s_{q6}\big)\Big)p_{12}+\big(\dot{q}_4\,\big(\tfrac{1}{2}s_{q4}-c_{q5}{}^2\,s_{q4}\big)-\dot{q}_3\,\big(\tfrac{1}{2}s_{2q_5}-c_{q4}{}^2\,c_{q5}\,s_{q5}\big)+\\
&\dot{q}_1\,\big(s_{q3}\,s_{q4}\,c_{q5}{}^2+c_{q3}\,c_{q4}\,s_{q4}\,s_{q5}\,c_{q5}-\tfrac{1}{2}s_{q3}\,s_{q4}\big)\Big)p_{13}+\big(\dot{q}_3\,\big(2c_{q5}\,s_{q5}\,s_{q6}\,c_{q6}-\\
&\tfrac{1}{2}s_{q5}\,s_{q6}\,c_{q4}{}^2\,c_{q6}-s_{q4}\,s_{q5}\,c_{q4}\,c_{q6}{}^2\big)-\dot{q}_1\big(2c_{q3}\,s_{q5}\,c_{q4}{}^2\,c_{q6}{}^2-s_{q3}\,c_{q4}\,c_{q5}\,c_{q6}{}^2+\\
&\tfrac{1}{2}s_{q3}\,c_{q4}\,c_{q5}\,c_{q6}-2s_{q3}\,s_{q4}\,s_{q6}\,c_{q5}{}^2\,c_{q6}-\tfrac{1}{2}3c_{q3}\,s_{q5}\,c_{q6}{}^2+2s_{q3}\,s_{q4}\,s_{q6}\,c_{q6}\big)-\\
&\dot{q}_4\Big(c_{q6}\,s_{q4}\,s_{q6}-c_{q5}{}^2\,c_{q6}\,s_{q4}\,s_{q6}\Big)-\dot{q}_6\,\big(c_{q5}\,s_{q4}\,s_{q6}\,c_{q6}-c_{q4}\,c_{q6}{}^2+\tfrac{1}{2}c_{q4}\big)-\\
&\dot{q}_5c_{q6}{}^2\,s_{q4}\,s_{q5}\big)p_{14}+\big(\dot{q}_3\,\big(2c_{q6}\,c_{q4}{}^2\,c_{q5}{}^2-c_{q6}\,c_{q4}{}^2+s_{q4}\,s_{q6}\,c_{q4}\,c_{q5}+2c_{q6}\,c_{q5}{}^2-\\
&c_{q6}\big)+\dot{q}_1\big(c_{q3}\,c_{q5}\,s_{q6}-c_{q3}\,c_{q4}{}^2\,c_{q5}\,s_{q6}+c_{q3}\,c_{q4}\,c_{q6}\,s_{q4}+c_{q5}\,c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}-\\
&2c_{q3}\,c_{q4}\,c_{q5}{}^2\,c_{q6}\,s_{q4}\big)+\dot{q}_5c_{q5}\,s_{q4}\,s_{q6}-\dot{q}_4c_{q5}\,c_{q6}\,s_{q4}\,s_{q5}\big)p_{15}-\\
&\dot{q}_2\big(\tfrac{1}{2}s_{q3}\,s_{q5}-\tfrac{1}{2}c_{q4}\,s_{q2}\,s_{q3}\,s_{q5}\,s_{q6}\big)p_{17}+\dot{q}_2\big(\tfrac{1}{2}c_{q2}\,c_{q4}\,s_{q3}\,s_{q5}+\tfrac{1}{2}c_{q2}\,c_{q3}\,c_{q4}\,c_{q5}\big)p_{18}+\\
&\big(\dot{q}_4c_{q6}\,s_{q4}\,s_{q5}-\dot{q}_3c_{q5}\,c_{q6}+\dot{q}_6c_{q4}\,s_{q5}\,s_{q6}-\dot{q}_5c_{q4}\,c_{q5}\,c_{q6}-\tfrac{1}{2}\dot{q}_1c_{q6}\,s_{q3}\,s_{q4}\,s_{q5}\big)p_{21}+\\
&\big(c_{q5}\,\dot{q}_3\,s_{q6}+c_{q4}\,c_{q5}\,\dot{q}_5\,s_{q6}-\dot{q}_4\,s_{q4}\,s_{q5}\,s_{q6}+\dot{q}_1\,s_{q3}\,s_{q4}\,s_{q5}\,s_{q6}\big)p_{22}+\big(\dot{q}_1c_{q5}\,s_{q3}\,s_{q4}-\\
&\dot{q}_4\,c_{q5}\,s_{q4}-\dot{q}_5c_{q4}\,s_{q5}-\dot{q}_3\,s_{q5}\big)p_{25}+\big(\dot{q}_1\Big(c_{q3}\,c_{q4}{}^2\,s_{q5}-c_{q3}\,s_{q5}\Big)-\dot{q}_5\,s_{q4}\,s_{q5}-\\
&\dot{q}_3c_{q4}\,s_{q4}\,s_{q5}\big)\big)p_{33}+\big(\tfrac{1}{2}\dot{q}_1\,s_{q3}\,s_{q4}-\tfrac{1}{2}\dot{q}_4\,s_{q4}\big)p_{36}+\tfrac{1}{2}\dot{q}_6c_{q5}\,s_{q4}\,p_{37}+\\
&\big(\dot{q}_1\Big(4c_{q3}\,c_{q4}\,s_{q4}\,c_{q5}{}^2-2c_{q3}\,c_{q4}\,s_{q4}-s_{q3}\,s_{q4}\,s_{q5}\Big)-\dot{q}_3\Big(-2c_{q4}{}^2\,c_{q5}{}^2+c_{q4}{}^2+4c_{q5}{}^2-2\Big)+\\
&2\dot{q}_4\,c_{q5}\,s_{q4}\,s_{q5}\big)p_{40}+\big(-\dot{q}_1\,\Big(c_{q3}\,c_{q5}-c_{q3}\,c_{q4}{}^2\,c_{q5}\Big)-c_{q5}\,\dot{q}_5\,s_{q4}-\dot{q}_3\,c_{q4}\,c_{q5}\,s_{q4}\big)p_{41}
\end{aligned}
\tag{B.90}
$$

$$C_{36} = \left(\dot{q}_3\left(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}\right)-\dot{q}_1\left(c_{q3}c_{q4}c_{q6}-c_{q3}c_{q5}s_{q4}s_{q6}+\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\right)+ c_{q5}\dot{q}_5 s_{q6}+c_{q6}\dot{q}_6 s_{q5}\right)p_5+\left(\dot{q}_1\left(c_{q3}c_{q4}s_{q6}+c_{q3}c_{q5}c_{q6}s_{q4}\right)-\dot{q}_3\left(s_{q4}s_{q6}- 2c_{q4}c_{q5}c_{q6}\right)+\dot{q}_5 c_{q5}c_{q6}-\dot{q}_6 s_{q5}s_{q6}\right)p_6+\left(\dot{q}_1\left(c_{q4}c_{q5}s_{q3}s_{q6}+c_{q3}{c_{q4}}^2 s_{q5}s_{q6}+ \tfrac{1}{2}{c_{q5}}^2 c_{q6}s_{q3}s_{q4}+c_{q3}c_{q4}{c_{q5}}^2 c_{q6}s_{q4}s_{q6}+\tfrac{1}{2}c_{q3}c_{q4}c_{q5}c_{q6}s_{q4}s_{q5}\right)-\dot{q}_3\left(c_{q5}c_{q6}s_{q5}- c_{q5}c_{q6}s_{q5}{c_{q4}}^2+s_{q4}s_{q5}s_{q6}c_{q4}\right)-\dot{q}_4\left(c_{q6}s_{q4}{c_{q5}}^2+c_{q4}s_{q6}c_{q5}\right)-\dot{q}_6\left(c_{q4}s_{q6}+ c_{q5}c_{q6}s_{q4}\right)\right)p_{11}+\left(\dot{q}_1\left(c_{q3}c_{q5}{c_{q4}}^2-2c_{q3}c_{q5}{c_{q4}}^2{c_{q6}}^2+s_{q3}s_{q5}c_{q4}{c_{q6}}^2+ c_{q3}s_{q4}s_{q6}c_{q4}c_{q6}-\tfrac{1}{2}s_{q3}s_{q5}c_{q4}+c_{q3}c_{q5}{c_{q6}}^2-c_{q5}s_{q3}s_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q3}c_{q5}\right)- \dot{q}_5\left(\tfrac{1}{2}c_{q5}s_{q4}-c_{q5}{c_{q6}}^2 s_{q4}\right)+\dot{q}_3\left(s_{q6}{c_{q4}}^2{c_{q5}}^2c_{q6}+s_{q6}{c_{q4}}^2c_{q6}+2s_{q4}c_{q4}c_{q5}{c_{q6}}^2- s_{q4}c_{q4}c_{q5}-s_{q6}{c_{q5}}^2c_{q6}\right)-\dot{q}_4\left(c_{q4}s_{q5}{c_{q6}}^2+c_{q5}s_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q4}s_{q5}\right)\right)p_{12}+ \dot{q}_4\left(c_{q5}s_{q4}s_{q5}{c_{q6}}^2+c_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q5}s_{q4}s_{q5}\right)+\dot{q}_3\left({c_{q4}}^2c_{q5}{c_{q6}}^2- \tfrac{1}{2}{c_{q4}}^2c_{q5}+{c_{q4}}^2{c_{q6}}^2-\tfrac{1}{2}{c_{q4}}^2-2s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}-2{c_{q5}}^2{c_{q6}}^2+{c_{q5}}^2\right)- \dot{q}_5\left(\tfrac{1}{2}c_{q4}-c_{q4}{c_{q6}}^2+c_{q5}s_{q4}s_{q6}c_{q6}\right)-\dot{q}_1\tfrac{3}{2}c_{q3}c_{q4}s_{q4}-c_{q5}s_{q3}s_{q4}s_{q5}+\tfrac{1}{2}c_{q4}s_{q3}s_{q5}s_{q6}- 3c_{q3}c_{q4}c_{q6}^2 s_{q4}+2c_{q3}c_{q5}c_{q6}s_{q6}-4c_{q3}{c_{q4}}^2c_{q5}c_{q6}s_{q6}+2c_{q5}c_{q6}^2 s_{q3}s_{q4}s_{q5}\right)p_{14}+ \left(\dot{q}_4\left(c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}{c_{q5}}^2 s_{q4}s_{q6}-2c_{q3}c_{q5}c_{q6}s_{q3}s_{q5}\right)-\dot{q}_3\left(c_{q5}s_{q5}s_{q6}{c_{q4}}^2- c_{q6}s_{q4}s_{q5}c_{q4}+c_{q5}s_{q5}s_{q6}\right)+\dot{q}_1\left(s_{q3}s_{q4}s_{q6}-c_{q3}{c_{q4}}^2c_{q6}s_{q5}+\tfrac{1}{2}{c_{q5}}^2s_{q3}s_{q4}s_{q6}- c_{q4}c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q5}s_{q4}s_{q5}s_{q6}\right)+\dot{q}_6\left(c_{q4}c_{q6}-c_{q5}s_{q4}s_{q6}\right)\right)p_{15}- \tfrac{1}{2}\dot{q}_2 c_{q2}c_{q3}c_{q4}c_{q5}c_{q6}p_{16}+\dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q3}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}\right)p_{17}+ \left(\dot{q}_1\left(c_{q4}c_{q6}s_{q3}-\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\right)-\dot{q}_4\left(c_{q4}c_{q6}-c_{q5}s_{q4}s_{q6}\right)+\dot{q}_6\left(s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}\right)+ \dot{q}_3 s_{q5}s_{q6}+\dot{q}_5 c_{q4}s_{q5}s_{q6}\right)\right)p_{21}+\left(\dot{q}_6\left(c_{q6}s_{q4}-c_{q4}c_{q5}s_{q6}\right)-\dot{q}_1\left(c_{q4}s_{q3}s_{q6}+ c_{q5}c_{q6}s_{q3}s_{q4}\right)+\dot{q}_4 c_{q4}s_{q6}+\dot{q}_3 c_{q6}s_{q5}\right)p_{22}+\dot{q}_1\left(\tfrac{1}{2}c_{q3}c_{q5}-\tfrac{1}{2}c_{q4}s_{q3}s_{q5}\right)+\tfrac{1}{2}c_{q4}\dot{q}_4 s_{q5}+ \tfrac{1}{2}c_{q5}\dot{q}_5 s_{q4}\right)p_{37} \tag{B.91}$$

$$C_{41} = \left(\dot{q}_3\left(c_{q3}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q3}c_{q6}s_{q4}-\tfrac{1}{2}c_{q3}s_{q4}s_{q6}-\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q3}\right)+ \dot{q}_6\left(\tfrac{1}{2}c_{q6}s_{q3}s_{q4}+\tfrac{1}{2}s_{q3}s_{q4}s_{q6}\right)-\dot{q}_1\left(c_{q5}c_{q6}s_{q4}-c_{q4}s_{q6}{c_{q3}}^2+c_{q4}s_{q6}\right)p_5+ \left(\dot{q}_1\left(c_{q5}s_{q4}s_{q6}-2c_{q4}c_{q6}+2{c_{q3}}^2c_{q4}c_{q6}-2{c_{q3}}^2c_{q5}s_{q4}s_{q6}\right)-\dot{q}_3\left(c_{q3}c_{q6}s_{q4}+ c_{q3}c_{q4}c_{q5}s_{q6}\right)\right)p_6+\left(\dot{q}_3 c_{q3}c_{q4}s_{q5}-\dot{q}_1\left(2s_{q4}s_{q5}-{c_{q3}}^2 s_{q4}s_{q5}\right)\right)p_7+ \left(\dot{q}_6\left(c_{q3}c_{q4}{c_{q5}}^2c_{q6}-c_{q3}c_{q4}c_{q6}-\tfrac{1}{2}c_{q3}c_{q5}s_{q4}s_{q6}-c_{q5}c_{q6}s_{q3}s_{q5}\right)- \dot{q}_1\left(s_{q4}s_{q5}s_{q6}{c_{q3}}^2c_{q4}c_{q5}-c_{q6}s_{q5}{c_{q3}}^2{c_{q4}}^2+\tfrac{1}{2}c_{q6}s_{q5}{c_{q3}}^2- c_{q6}s_{q3}c_{q3}c_{q4}c_{q5}+2s_{q3}s_{q4}s_{q6}c_{q3}{c_{q5}}^2-\tfrac{1}{2}s_{q3}s_{q4}s_{q6}c_{q3}\right)- \dot{q}_3\left(c_{q3}s_{q5}s_{q6}{c_{q4}}^2c_{q5}-c_{q3}{c_{q4}}^2{c_{q5}}^2{c_{q6}}^2+\tfrac{3}{2}s_{q3}s_{q6}c_{q4}{c_{q5}}^2+2c_{q3}s_{q4}s_{q5}c_{q4}c_{q6}- s_{q3}s_{q6}c_{q4}+\tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2+\tfrac{3}{2}s_{q3}s_{q4}c_{q5}c_{q6}+\tfrac{1}{2}c_{q3}s_{q5}s_{q6}c_{q5}-\dot{q}_5\left(2s_{q3}s_{q6}{c_{q5}}^2+ 2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}-s_{q3}s_{q6}+\tfrac{3}{2}c_{q3}c_{q6}s_{q4}s_{q5}\right)p_{11}+\left(\dot{q}_6\left(s_{q3}s_{q6}c_{q6}-s_{q3}s_{q6}{c_{q5}}^2c_{q6}- c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6}-c_{q3}s_{q4}s_{q5}{c_{q6}}^2+\tfrac{1}{2}c_{q3}s_{q4}s_{q5}\right)-\dot{q}_5\left(\tfrac{1}{2}c_{q3}c_{q4}{c_{q6}}^2+ c_{q5}{c_{q6}}^2s_{q3}s_{q5}-c_{q3}c_{q4}{c_{q5}}^2{c_{q6}}^2+c_{q3}c_{q5}c_{q6}s_{q4}s_{q6}-\tfrac{1}{2}c_{q3}c_{q5}{c_{q6}}^2s_{q4}s_{q5}\right)- \dot{q}_3\left(s_{q3}s_{q5}c_{q4}c_{q5}{c_{q6}}^2-c_{q3}{c_{q4}}^2{c_{q6}}^2+2c_{q3}s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q3}{c_{q5}}^2{c_{q6}}^2+ c_{q3}{c_{q6}}^2-s_{q3}s_{q4}s_{q5}s_{q6}c_{q6}\right)-\dot{q}_1\left(s_{q6}{c_{q3}}^2c_{q5}c_{q6}-2s_{q6}{c_{q3}}^2{c_{q4}}^2c_{q5}c_{q6}- \right. \tag{B.92}$$

$$
\begin{aligned}
&s_{q4}c_{q3}{}^2c_{q4}c_{q6}{}^2 - s_{q4}c_{q3}c_{q4}c_{q5}{}^2c_{q6}{}^2 + s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}c_{q6} + s_{q3}s_{q4}s_{q5}c_{q3}c_{q5}c_{q6}{}^2 + \\
&s_{q3}s_{q4}c_{q5}c_{q6})\big)p_{12} + \big(\tfrac{1}{2}\dot{q}_6 s_{2q_6} + \dot{q}_1\big(c_{q3}{}^2c_{q4}c_{q5}{}^2s_{q4} - \tfrac{1}{2}c_{q3}c_{q5}s_{q3}s_{q4}s_{q5}\big) + \\
&\dot{q}_3\big(c_{q3}c_{q4}{}^2c_{q5}{}^2 - c_{q4}c_{q5}s_{q3}s_{q5}\big) - \dot{q}_5\big(s_{q3}s_{q5}c_{q5} - c_{q3}c_{q4}c_{q5}{}^2 + \tfrac{1}{2}c_{q3}c_{q4}\big)\big)p_{13} + \\
&\big(\dot{q}_1\big(4c_{q3}{}^2c_{q4}{}^2c_{q5}c_{q6}{}^2 - 2s_{q4}s_{q6}c_{q3}{}^2c_{q4}c_{q5}{}^2c_{q6} - 2c_{q3}{}^2c_{q5}c_{q6}{}^2 - \\
&2s_{q3}s_{q5}c_{q3}c_{q4}c_{q6}{}^2 + 2s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}c_{q5}c_{q6}\big) + \dot{q}_3\big(\tfrac{7}{2}c_{q3}c_{q6}s_{q6} + c_{q6}s_{q3}s_{q4}s_{q5} - \\
&3c_{q3}c_{q4}{}^2c_{q6}s_{q6} - 2c_{q3}c_{q5}{}^2c_{q6}s_{q6} + 2c_{q6}{}^2s_{q3}s_{q4}s_{q5} - 4c_{q3}c_{q4}c_{q5}c_{q6}{}^2s_{q4} + \\
&3c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}s_{q6}\big) + \dot{q}_6\big(2s_{q3}c_{q5}{}^2 - 4s_{q3}c_{q5}{}^2c_{q6}{}^2 - 4c_{q3}c_{q4}s_{q5}c_{q5}c_{q6}{}^2 + \\
&\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q3} + 4s_{q3}c_{q6}{}^2 + 4c_{q3}s_{q4}s_{q5}s_{q6}c_{q6} - 2s_{q3}\big) - \dot{q}_5\big(4c_{q3}c_{q4}s_{q6}c_{q5}{}^2c_{q6} + \\
&3c_{q3}s_{q4}c_{q5}c_{q6}{}^2 - 4s_{q3}s_{q5}s_{q6}c_{q5}c_{q6} - c_{q3}c_{q4}s_{q6}c_{q6}\big)p_{14} + \big(\dot{q}_6\big(\tfrac{1}{2}c_{q3}c_{q4}s_{q6}c_{q5}{}^2 - \\
&s_{q3}s_{q5}s_{q6}c_{q5} - \tfrac{1}{2}c_{q3}c_{q4}s_{q6}\big) + \dot{q}_1\big(2s_{q5}s_{q6}c_{q3}{}^2c_{q4}{}^2 + 2s_{q4}s_{q5}s_{q6}c_{q3}{}^2c_{q4}c_{q5}c_{q6}{}^2 + \\
&2s_{q4}s_{q5}c_{q3}{}^2c_{q4}c_{q5}c_{q6} - s_{q5}s_{q6}c_{q3}{}^2 + s_{q3}s_{q6}c_{q3}c_{q4}c_{q5} + s_{q3}s_{q4}c_{q3}c_{q5}{}^2c_{q6}\big) + \\
&\dot{q}_3\big(c_{q4}c_{q6}s_{q3} - c_{q5}s_{q3}s_{q4}s_{q6} + c_{q4}c_{q5}{}^2c_{q6}s_{q3} - 2c_{q3}c_{q4}s_{q4}s_{q5}s_{q6} + 2c_{q3}c_{q4}{}^2c_{q5}c_{q6}s_{q5}\big) + \\
&\dot{q}_5\big(2c_{q6}s_{q3}c_{q5}{}^2 + c_{q3}c_{q4}c_{q6}s_{q5}c_{q5} - c_{q6}s_{q3} - c_{q3}s_{q4}s_{q5}s_{q6}\big) + \tfrac{1}{2}\dot{q}_2\,c_{q2}c_{q4}\;s_{q5}\big)p_{15} + \\
&\big(\dot{q}_2\,\big(\tfrac{1}{2}c_{q2}c_{q4}c_{q5}c_{q6} - c_{q2}s_{q4}s_{q6}\big) - \dot{q}_1\big(c_{q4}s_{q2}s_{q3}s_{q6} + 2c_{q5}c_{q6}s_{q2}s_{q3}s_{q4}\big)\big)p_{16} + \\
&\big(\dot{q}_1\big(2c_{q5}s_{q2}s_{q3}s_{q4}s_{q6} - 2c_{q4}c_{q6}s_{q2}\big) - c_{q2}c_{q6}\dot{q}_2s_{q4}\big)p_{17} + \dot{q}_2\,c_{q2}c_{q4}\;s_{q5}\,p_{18} + \\
&\dot{q}_3\big(s_{q3}s_{q4}s_{q6} - \tfrac{1}{2}c_{q4}\,c_{q5}\,c_{q6}\,s_{q3}\big) + \big(\dot{q}_1\,\big(c_{q5}s_{q3}s_{q4}s_{q6} - c_{q3}c_{q4}s_{q3}s_{q6} - c_{q6}s_{q2}s_{q3}s_{q4} - \\
&c_{q3}c_{q5}c_{q6}s_{q3}s_{q4} + c_{q5}{}^2c_{q6}s_{q2}s_{q3}s_{q4}\big)\big)p_{21} + \dot{q}_3\big(c_{q6}s_{q3}s_{q4} + c_{q4}c_{q5}s_{q3}s_{q6}\big) - \\
&\dot{q}_1\big(c_{q3}c_{q4}c_{q6}s_{q3} - c_{q3}c_{q5}s_{q3}s_{q4}s_{q6}\big)\big)p_{22} - \dot{q}_1\,c_{q4}s_{q3}s_{q6}\,p_{23} + \dot{q}_6\big(\tfrac{1}{2}c_{q4}c_{q6} - \\
&\tfrac{1}{2}s_{q4}s_{q6}\big) - \dot{q}_1c_{q4}c_{q6}s_{q3}\big)p_{24} - \big(\dot{q}_3\,c_{q4}\,s_{q3}s_{q5} + \dot{q}_1\,c_{q3}s_{q3}s_{q4}s_{q5}\big)p_{25} \\
&\big(\tfrac{1}{2}\dot{q}_5\,c_{q4}c_{q5} - \dot{q}_1s_{q3}s_{q4}s_{q5}\big)p_{32} + \dot{q}_1\big(2c_{q5}c_{q3}{}^2c_{q4}{}^2 - c_{q5}c_{q3}{}^2 + s_{q3}s_{q5}c_{q3}c_{q4}\big) + \\
&\dot{q}_3\big(s_{q3}s_{q4}s_{q5} - 2c_{q3}c_{q4}c_{q5}s_{q4}\big) - \dot{q}_5\,c_{q3}c_{q5}\,s_{q4}\big)p_{33} + \big(\dot{q}_3\,\big(\tfrac{1}{2}c_{q3} - c_{q3}c_{q4}{}^2\big) - \\
&\dot{q}_1\,c_{q3}{}^2c_{q4}\,s_{q4}\big)p_{34} - \tfrac{1}{2}\dot{q}_3\,c_{q3}\,p_{35} - \tfrac{1}{2}\dot{q}_5\,c_{q3}c_{q4}\,p_{36} - \tfrac{1}{2}\dot{q}_6\,c_{q3}\,s_{q4}s_{q5}\,p_{37} + \\
&\big(-\dot{q}_3\big(4c_{q3}s_{q5}c_{q4}{}^2c_{q5} + s_{q3}c_{q4}c_{q5}{}^2 + s_{q3}c_{q4}c_{q5}\big) - \dot{q}_1\big(2c_{q4}s_{q4}s_{q5}c_{q3}{}^2c_{q5} + \\
&2s_{q3}s_{q4}c_{q3}c_{q5}{}^2\big) - \dot{q}_5\big(4s_{q3}c_{q5}{}^2 + 2\,c_{q3}\,c_{q4}\,s_{q5}\,c_{q5} - 2s_{q3}\big)p_{40} + \big(\dot{q}_1\big(2s_{q5}c_{q3}{}^2 - \\
&4s_{q5}c_{q3}{}^2c_{q4}{}^2 - c_{q5}s_{q3}c_{q3}c_{q4}\big) + \big(\dot{q}_3\big(c_{q5}s_{q3}s_{q4} + 2c_{q3}c_{q4}s_{q4}s_{q5}\big) + \dot{q}_5\,c_{q3}\,s_{q4}s_{q5}\,p_{41}\big) + \\
&\big(\dot{q}_1\,\big(-c_{q3}{}^2 + 2c_{q3}{}^2c_{q4}{}^2\big) - 2\dot{q}_3\,c_{q3}c_{q4}s_{q4}\big)p_{42} + \big(\dot{q}_3s_{q3}s_{q4} - \dot{q}_1\,c_{q3}c_{q4}\,s_{q3}\big)p_{43} - \\
&\big(c_{q4}\dot{q}_3s_{q3} + \dot{q}_1\,c_{q3}\,s_{q3}s_{q4}\big)p_{48}
\end{aligned}
$$

$$
\begin{aligned}
C_{42} = {} & \tfrac{1}{2}\dot{q}_1\,c_{q2}\,c_{q4}\,s_{q5}\,p_{15} + \big(\tfrac{1}{2}\dot{q}_6\,c_{q2}\,c_{q5}\,c_{q6}\;s_{q3}\,s_{q4} - \dot{q}_1\,\big(c_{q2}s_{q4}s_{q6} - \tfrac{1}{2}c_{q2}c_{q4}c_{q5}c_{q6}\big) - \\
& \dot{q}_2\big(c_{q4}s_{q2}s_{q3}s_{q6} + c_{q2}c_{q3}c_{q4}s_{q6} + c_{q2}c_{q3}c_{q5}c_{q6}s_{q4} + c_{q5}c_{q6}s_{q2}s_{q3}s_{q4}\big)\big)p_{16} + \\
& \big(-\dot{q}_2\,\big(c_{q4}c_{q6}s_{q2}s_{q3} + c_{q2}c_{q3}c_{q4}c_{q6} - c_{q2}c_{q3}c_{q5}s_{q4}s_{q6} - c_{q5}s_{q2}s_{q3}s_{q4}s_{q6}\big) - \\
& \dot{q}_1\,c_{q2}c_{q6}\,s_{q4} - \tfrac{1}{2}\dot{q}_3\,c_{q5}\,s_{q2}s_{q3}s_{q4}s_{q6} - \tfrac{1}{2}\dot{q}_6\,c_{q2}\,c_{q5}\,c_{q6}\;s_{q3}\,s_{q4}\big)p_{17} + \\
& \big(\tfrac{1}{2}\dot{q}_1\,c_{q2}\,c_{q4}\,s_{q5} - \dot{q}_3\,\big(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q3}\,s_{q4} + \tfrac{1}{2}s_{q2}\,s_{q3}\,s_{q4}\,s_{q5}\big) - \dot{q}_5\,\big(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q3}\,s_{q4} - \\
& \tfrac{1}{2}c_{q3}\,c_{q5}\,s_{q2}\,s_{q4}\big)\big)p_{18} + \dot{q}_5\,\big(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q3}\,s_{q4} - \tfrac{1}{2}c_{q3}\,c_{q5}\,s_{q2}\,s_{q4}\big) - \dot{q}_2\,\big(c_{q2}c_{q3}s_{q4}s_{q5} + \\
& s_{q2}s_{q3}s_{q4}s_{q5}\big) + \dot{q}_3\,\tfrac{1}{2}\big(c_{q2}c_{q3}s_{q4}s_{q5} + s_{q2}\,s_{q3}\,s_{q4}\,s_{q5}\big)\big)p_{38}
\end{aligned}
\tag{B.93}
$$

$$
\begin{aligned}
C_{43} = {} & \left(\dot{q}_1\left(-\tfrac{1}{2}c_{q3}c_{q6}s_{q4}-\tfrac{1}{2}c_{q3}s_{q4}s_{q6}+c_{q3}c_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q4}c_{q5}c_{q6}s_{q3}\right)-\dot{q}_3\left(c_{q4}s_{q6}+\right.\right. \\
& \left.\left.c_{q5}c_{q6}s_{q4}\right)\right)p_5+\left(-\dot{q}_1\left(c_{q3}c_{q6}s_{q4}+c_{q3}c_{q4}c_{q5}s_{q6}\right)-\dot{q}_3\left(c_{q4}c_{q6}-2c_{q5}s_{q4}s_{q6}\right)\right)p_6+ \\
& \left(c_{q3}c_{q4}\dot{q}_1s_{q5}-\dot{q}_3s_{q4}s_{q5}\right)p_7+\left(\dot{q}_6\left(c_{q6}s_{q4}-c_{q5}{}^2c_{q6}s_{q4}\right)+\dot{q}_3\left(2c_{q5}s_{q4}s_{q5}s_{q6}c_{q4}-\right.\right. \\
& \left.\left.2c_{q6}s_{q5}c_{q4}{}^2+c_{q6}s_{q5}\right)-\dot{q}_5\left(c_{q4}c_{q6}s_{q5}-2c_{q5}s_{q4}s_{q5}s_{q6}\right)+\dot{q}_1\left(c_{q3}c_{q4}{}^2c_{q5}{}^2c_{q6}{}^2-\right.\right. \\
& \left.\left.c_{q3}s_{q5}s_{q6}c_{q4}{}^2c_{q5}-\tfrac{3}{2}s_{q3}s_{q6}c_{q4}c_{q5}{}^2-2c_{q3}s_{q4}s_{q5}c_{q4}c_{q6}+s_{q3}s_{q6}c_{q4}-\tfrac{1}{2}c_{q3}c_{q5}{}^2c_{q6}{}^2-\right.\right. \\
& \left.\left.\tfrac{3}{2}s_{q3}s_{q4}c_{q5}c_{q6}-\tfrac{1}{2}c_{q3}s_{q5}s_{q6}c_{q5}\right)p_{11}+\left(\dot{q}_1\left(c_{q3}c_{q4}{}^2c_{q6}{}^2-{}_{q3}s_{q5}c_{q4}c_{q5}c_{q6}{}^2-\right.\right.\right. \\
& \left.\left.\left.2c_{q3}s_{q4}s_{q6}c_{q4}c_{q5}c_{q6}+\tfrac{1}{2}c_{q3}c_{q5}{}^2c_{q6}{}^2-c_{q3}c_{q6}{}^2+s_{q3}s_{q4}s_{q5}s_{q6}c_{q6}\right)-\right. \\
& \dot{q}_3\left(2s_{q6}c_{q4}{}^2c_{q5}c_{q6}+s_{q4}c_{q4}c_{q5}{}^2c_{q6}{}^2+s_{q4}c_{q4}c_{q6}{}^2-s_{q6}c_{q5}c_{q6}-\tfrac{1}{2}s_{2q_4}\right)- \\
& \dot{q}_5\left(\tfrac{1}{2}s_{q4}c_{q5}{}^2-s_{q4}c_{q5}{}^2c_{q6}{}^2+c_{q4}s_{q6}c_{q5}c_{q6}+\tfrac{1}{2}s_{q4}c_{q6}{}^2\right)- \\
& \left.\dot{q}_6\left(c_{q4}s_{q5}c_{q6}{}^2+c_{q5}s_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q4}s_{q5}\right)\right)p_{12}+\left(\dot{q}_1\left(c_{q3}c_{q4}{}^2c_{q5}{}^2-\right.\right. \\
& \left.\left.c_{q4}c_{q5}s_{q3}s_{q5}\right)+\dot{q}_5\left(\tfrac{1}{2}s_{q4}-c_{q5}{}^2s_{q4}\right)-c_{q4}c_{q5}{}^2\dot{q}_3s_{q4}\right)p_{13}+\left(\dot{q}_6\,c_{q5}s_{q4}s_{q5}c_{q6}{}^2+\right. \\
& c_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q5}s_{q4}s_{q5}+\dot{q}_3\left(c_{q5}c_{q6}{}^2-2c_{q4}{}^2c_{q5}c_{q6}{}^2+c_{q4}c_{q6}s_{q4}s_{q6}+\right. \\
& \left.c_{q4}c_{q5}c_{q6}s_{q4}s_{q6}\right)-\dot{q}_5\left(c_{q4}c_{q5}c_{q6}{}^2-c_{q5}{}^2c_{q6}s_{q4}s_{q6}\right)+\dot{q}_1\left(\tfrac{7}{2}c_{q3}c_{q6}s_{q6}+\right. \\
& \tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5}-3c_{q3}c_{q4}{}^2c_{q6}s_{q6}-2c_{q3}c_{q5}{}^2c_{q6}s_{q6}+2c_{q6}{}^2s_{q3}s_{q4}s_{q5}- \\
& \left.4c_{q3}c_{q4}c_{q5}c_{q6}{}^2s_{q4}+3c_{q4}c_{q5}c_{q6}s_{q3}s_{q5}s_{q6}\right)p_{14}+\left(\dot{q}_1\left(\tfrac{1}{2}c_{q4}c_{q6}s_{q3}-\right.\right. \\
& \left.\left.c_{q5}s_{q3}s_{q4}s_{q6}+c_{q4}c_{q5}{}^2c_{q6}s_{q3}-2c_{q3}c_{q4}s_{q4}s_{q5}s_{q6}+2c_{q3}c_{q4}{}^2c_{q5}c_{q6}s_{q5}\right)- \\
& \dot{q}_5\left(c_{q4}s_{q5}s_{q6}+c_{q5}c_{q6}s_{q4}s_{q5}\right)+\dot{q}_3\left(2c_{q5}c_{q6}s_{q4}s_{q5}c_{q4}-2s_{q5}s_{q6}c_{q4}{}^2+s_{q5}s_{q6}\right)+ \\
& \left.\dot{q}_6\left(s_{q4}s_{q6}-\tfrac{1}{2}s_{q4}s_{q6}c_{q5}{}^2+2c_{q3}c_{q6}s_{q3}s_{q5}c_{q5}\right)\right)p_{15}-\dot{q}_2\,c_{q5}\,s_{q2}s_{q3}s_{q4}s_{q6}\,p_{17}- \\
& \dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q5}s_{q3}s_{q4}+\tfrac{1}{2}s_{q2}s_{q3}s_{q4}s_{q5}\right)p_{18}+\dot{q}_1\left(s_{q3}s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}s_{q3}\right)p_{21}+ \\
& \left(\dot{q}_1\left(c_{q6}s_{q3}s_{q4}+c_{q4}c_{q5}s_{q3}s_{q6}\right)+c_{q5}c_{q6}\dot{q}_6s_{q4}\right)p_{22}-c_{q4}\dot{q}_1s_{q3}s_{q5}\,p_{25}+ \\
& \left(\dot{q}_3\left(c_{q5}-2c_{q4}{}^2c_{q5}\right)+\dot{q}_1\left(s_{q3}s_{q4}s_{q5}-2c_{q3}c_{q4}c_{q5}s_{q4}\right)-\dot{q}_5\,c_{q4}c_{q5}\right)p_{33}+ \\
& \dot{q}_1\left(\tfrac{1}{2}c_{q3}-c_{q3}c_{q4}{}^2\right)p_{34}-\tfrac{1}{2}c_{q3}\dot{q}_1\,p_{35}+\tfrac{1}{2}\dot{q}_5s_{q4}\,p_{36}-\dot{q}_6\,c_{q4}s_{q5}\,p_{37}+ \\
& \dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q3}s_{q4}s_{q5}+s_{q2}s_{q3}s_{q4}s_{q5}\right)p_{38}-\left(\dot{q}_1\left(4c_{q3}s_{q5}c_{q4}{}^2c_{q5}+s_{q3}c_{q4}c_{q5}{}^2+\right.\right. \\
& \left.\left.s_{q3}c_{q4}c_{q5}\right)+2c_{q5}\dot{q}_5s_{q4}s_{q5}+2c_{q4}c_{q5}\dot{q}_3s_{q4}s_{q5}\right)p_{40}+\dot{q}_1\left(c_{q5}s_{q3}s_{q4}+\right. \\
& \left.2c_{q3}c_{q4}s_{q4}s_{q5}\right)-\dot{q}_3\left(s_{q5}-2c_{q4}{}^2s_{q5}\right)+\dot{q}_5\,c_{q4}\,s_{q5}\Big)p_{41}-\left(\dot{q}_3\left(2c_{q4}{}^2-1\right)-\right. \\
& \left.2\dot{q}_1\,c_{q3}c_{q4}\,s_{q4}\right)p_{42}+\left(\dot{q}_1s_{q3}s_{q4}\right)p_{43}+\left(-c_{q4}\dot{q}_1s_{q3}\right)p_{48}
\end{aligned}
\tag{B.94}
$$

$$
\begin{aligned}
C_{44} = {} & \left(\dot{q}_6\,c_{q5}c_{q6}s_{q5}-\dot{q}_5\left(s_{q6}-2c_{q5}{}^2s_{q6}\right)\right)p_{11}+c_{q5}c_{q6}{}^2\dot{q}_5s_{q5}-\dot{q}_6\left(c_{q6}s_{q6}-\right. \\
& \left.c_{q5}{}^2c_{q6}s_{q6}\right)\Big)p_{12}+\left(c_{q5}\dot{q}_5s_{q5}\right)p_{13}+\left(\dot{q}_6\left(c_{q5}{}^2c_{q6}{}^2-\tfrac{1}{2}c_{q5}{}^2-2c_{q6}{}^2+1\right)-\right. \\
& \left.c_{q5}c_{q6}\dot{q}_5s_{q5}s_{q6}\right)p_{14}+\left(\dot{q}_5\left(c_{q6}-2c_{q5}{}^2c_{q6}\right)+c_{q5}\dot{q}_6s_{q5}s_{q6}\right)p_{15}+\dot{q}_5\left(2c_{q5}{}^2-1\right)p_{40}
\end{aligned}
\tag{B.95}
$$

$$C_{45} = \left(\dot{q}_4\left(+2c_{q5}^{\,2}s_{q6} - s_{q6}\right) - \dot{q}_3\left(c_{q4}c_{q6}s_{q5} - 2c_{q5}s_{q4}s_{q5}s_{q6}\right) - \dot{q}_1\left(2s_{q3}s_{q6}c_{q5}^{\,2} + 2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5} - s_{q3}s_{q6} + \tfrac{3}{2}c_{q3}c_{q6}s_{q4}s_{q5}\right) - \dot{q}_5\,c_{q6}s_{q5}\right)p_{11} + \left(\dot{q}_1\left(\tfrac{1}{2}c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}^{\,2} - c_{q3}c_{q4}c_{q6}^{\,2} - c_{q5}c_{q6}^{\,2}s_{q3}s_{q5} - c_{q3}c_{q5}c_{q6}s_{q4}s_{q6} + c_{q3}c_{q5}c_{q6}^{\,2}s_{q4}s_{q5}\right) + \dot{q}_6\left(\tfrac{1}{2}s_{q5} - c_{q6}^{\,2}s_{q5}\right) - \dot{q}_3\left(\tfrac{1}{2}s_{q4}c_{q5}^{\,2} - s_{q4}c_{q5}^{\,2}c_{q6}^{\,2} + c_{q4}s_{q6}c_{q5}c_{q6} + \tfrac{1}{2}s_{q4}c_{q6}^{\,2}\right) - \dot{q}_5\,c_{q5}c_{q6}s_{q6} + \dot{q}_4\,c_{q5}c_{q6}^{\,2}\,s_{q5}\right)p_{12} + \tfrac{1}{2}\dot{q}_4\sin\left(2q_5\right) + \dot{q}_3\left(\tfrac{1}{2}s_{q4} - c_{q5}^{\,2}s_{q4}\right) - \dot{q}_1\left(s_{q3}s_{q5}c_{q5} - c_{q3}c_{q4}c_{q5}^{\,2} + \tfrac{1}{2}c_{q3}c_{q4}\right)p_{13} - \left(\dot{q}_3\left(c_{q4}c_{q5}c_{q6}^{\,2} - c_{q5}^{\,2}c_{q6}s_{q4}s_{q6}\right) + \dot{q}_1\left(4c_{q3}c_{q4}s_{q6}c_{q5}^{\,2}c_{q6} + 3c_{q3}s_{q4}c_{q5}c_{q6}^{\,2} - 4s_{q3}s_{q5}s_{q6}c_{q5}c_{q6} - c_{q3}c_{q4}s_{q6}c_{q6}\right) + \dot{q}_5\,c_{q5}c_{q6}^{\,2} - \dot{q}_6\,c_{q6}s_{q5}s_{q6} + \dot{q}_4\,c_{q5}c_{q6}\,s_{q5}s_{q6}\right)p_{14} + \left(\dot{q}_4\left(2c_{q5}^{\,2}c_{q6} - c_{q6}\right) - \left(\dot{q}_1\left(c_{q6}s_{q3} - 2c_{q6}s_{q3}c_{q5}^{\,2} - c_{q3}c_{q4}c_{q6}s_{q5}c_{q5} + c_{q3}s_{q4}s_{q5}s_{q6}\right) - \dot{q}_3\left(c_{q4}s_{q5}s_{q6} + c_{q5}c_{q6}s_{q4}s_{q5}\right) + \dot{q}_6\left(c_{q3}^{\,2}c_{q6} - 2c_{q3}^{\,2}c_{q5}^{\,2}c_{q6}\right) - \dot{q}_5\,s_{q5}s_{q6}\right)p_{15} - \dot{q}_2\left(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q3}\,s_{q4} - \tfrac{1}{2}c_{q3}\,c_{q5}\,s_{q2}\,s_{q4}\right)p_{18} + \tfrac{1}{2}c_{q4}\,c_{q5}\dot{q}_1\,p_{32} - \left(\dot{q}_5\,c_{q5} + \dot{q}_3\,c_{q4}\,c_{q5} + \dot{q}_1\,c_{q3}\,c_{q5}\,s_{q4}\right)p_{33} + \left(\tfrac{1}{2}\dot{q}_3\,s_{q4} - \tfrac{1}{2}\dot{q}_1\,c_{q3}\,c_{q4}\right)p_{36} + \dot{q}_2\left(\tfrac{1}{2}c_{q2}\,c_{q5}\,s_{q3}\,s_{q4} - \tfrac{1}{2}c_{q3}\,c_{q5}\,s_{q2}\,s_{q4}\right)p_{38}$$
$$\left(\dot{q}_4\left(2c_{q5}^{\,2} - 1\right) - \dot{q}_1\left(4s_{q3}c_{q5}^{\,2} + 2c_{q3}c_{q4}s_{q5}c_{q5} - 2s_{q3}\right) + 2c_{q5}\dot{q}_3\,s_{q4}\,s_{q5}\right)p_{40} + \left(\dot{q}_5\,s_{q5} + c_{q4}\,\dot{q}_3\,s_{q5} + c_{q3}\,\dot{q}_1\,s_{q4}\,s_{q5}\right)p_{41} \tag{B.96}$$

$$C_{46} = \dot{q}_1\left(\tfrac{1}{2}c_{q6}s_{q3}s_{q4} + {}_{q6}\;s_{q3}s_{q4}s_{q6}\right)p_5 + \left(\dot{q}_3\left(c_{q6}s_{q4} - c_{q5}^{\,2}c_{q6}s_{q4}\right) - \dot{q}_1\left(c_{q3}c_{q4}c_{q6} + \tfrac{1}{2}c_{q3}c_{q5}s_{q4}s_{q6} + c_{q5}c_{q6}s_{q3}s_{q5} - c_{q3}c_{q4}c_{q5}^{\,2}c_{q6}\right) + \dot{q}_6\,c_{q6}s_{q5} + \dot{q}_4\,c_{q5}c_{q6}s_{q5}\right)\right)p_{11} + \left(\dot{q}_1\left(s_{q3}s_{q6}c_{q6} - s_{q3}s_{q6}c_{q5}^{\,2}c_{q6} - c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6} - c_{q3}s_{q4}s_{q5}c_{q6}^{\,2} + \tfrac{1}{2}c_{q3}s_{q4}s_{q5}\right) + \dot{q}_5\left(\tfrac{1}{2}s_{q5} - c_{q6}^{\,2}s_{q5}\right) - \dot{q}_4\left(\tfrac{1}{2}s_{2q_6} - c_{q5}^{\,2}c_{q6}s_{q6}\right) - \dot{q}_3\left(c_{q4}s_{q5}c_{q6}^{\,2} + c_{q5}s_{q4}s_{q5}s_{q6}c_{q6} - \tfrac{1}{2}c_{q4}s_{q5}\right)\right)p_{12} + \dot{q}_1\,s_{2q_6}\,p_{13} + \left(\dot{q}_3\left(c_{q5}s_{q4}s_{q5}c_{q6}^{\,2} + c_{q4}s_{q5}s_{q6}c_{q6} - \tfrac{1}{2}c_{q5}s_{q4}s_{q5}\right) - \dot{q}_4\left(2c_{q6}^{\,2} - c_{q5}^{\,2}c_{q6}^{\,2} + \tfrac{1}{2}c_{q5}^{\,2} - 1\right) + \dot{q}_1\left(2s_{q3}c_{q5} - 4s_{q3}c_{q5}^{\,2}c_{q6}^{\,22} - 4c_{q3}c_{q4}s_{q5}c_{q5}c_{q6}^{\,2} + 2c_{q3}c_{q4}s_{q5}c_{q5} + 4s_{q3}c_{q6}^{\,2} + 4c_{q3}s_{q4}s_{q5}s_{q6}c_{q6} - 2s_{q3}\right) + \dot{q}_5\,c_{q6}\,s_{q5}s_{q6}\right)p_{14} + \left(-\dot{q}_1\left(s_{q3}s_{q5}s_{q6}c_{q5} - \tfrac{1}{2}c_{q3}c_{q4}s_{q6}c_{q5}^{\,2} + \tfrac{1}{2}c_{q3}c_{q4}s_{q6}\right) + \dot{q}_6\left(2c_{q5}s_{q5}s_{q6}c_{q3}^{\,2} + s_{q5}s_{q6}\right) + \dot{q}_3\left(2c_{q3}c_{q6}s_{q3}s_{q5}c_{q5} - \tfrac{1}{2}s_{q4}s_{q6}c_{q5}^{\,2} + s_{q4}s_{q6}\right) + \dot{q}_5\left(c_{q3}^{\,2}c_{q6} - 2c_{q3}^{\,2}c_{q5}^{\,2}c_{q6}\right) - \dot{q}_4\,c_{q5}s_{q5}s_{q6}\right)p_{15} + \tfrac{1}{2}\dot{q}_2\,c_{q2}\,c_{q5}\,c_{q6}\;s_{q3}\,s_{q4}\,p_{16} - \tfrac{1}{2}\dot{q}_2\,c_{q2}\,c_{q5}\,c_{q6}\;s_{q3}\,s_{q4}\,p_{17} + c_{q5}c_{q6}\dot{q}_3\,s_{q4}\,p_{22} + \dot{q}_1\left(\tfrac{1}{2}c_{q4}\,c_{q6} - \tfrac{1}{2}s_{q4}\,s_{q6}\right)p_{24} - \left(\tfrac{1}{2}\dot{q}_3\,c_{q4}\,s_{q5} + \tfrac{1}{2}\dot{q}_1\,c_{q3}\,s_{q4}\,s_{q5}\right)p_{37} \tag{B.97}$$

$$
\begin{aligned}
C_{51} = {} & \Big(\dot{q}_1\big(c_{q3}c_{q5}c_{q6}-c_{q4}c_{q6}s_{q5}-c_{q3}c_{q5}s_{q3}s_{q6}+c_{q3}c_{q5}c_{q6}s_{q3}\big)-\dot{q}_3\big(c_{q3}c_{q6}s_{q4}s_{q5}- \\
& \tfrac{1}{2}c_{q6}s_{q3}s_{q4}s_{q5}\big)\Big)p_5+\big(\dot{q}_1\big(c_{q4}s_{q5}s_{q6}-2c_{q4}s_{q5}s_{q6}{c_{q3}}^2-2c_{q5}s_{q6}c_{q3}\big)+ \\
& c_{q3}\dot{q}_3s_{q4}s_{q5}s_{q6}\big)p_6+\big(\dot{q}_1\big(2c_{q4}c_{q5}-c_{q4}c_{q5}{c_{q3}}^2+s_{q3}s_{q5}c_{q3}\big)+\dot{q}_3c_{q3}c_{q5}s_{q4}\big)p_7+ \\
& \big(\dot{q}_1\big(s_{q6}{c_{q3}}^2{c_{q4}}^2{c_{q5}}^2-\tfrac{1}{2}s_{q6}{c_{q3}}^2{c_{q4}}^2+\tfrac{1}{2}c_{q6}s_{q4}{c_{q3}}^2c_{q4}c_{q5}+2s_{q6}{c_{q3}}^2{c_{q5}}^2-s_{q6}{c_{q3}}^2- \\
& 4s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}c_{q5}-c_{q6}s_{q3}s_{q4}s_{q5}c_{q3}-s_{q6}{c_{q5}}^2+\tfrac{1}{2}s_{q6}\big)-\dot{q}_3\big(-c_{q3}{c_{q4}}^2c_{q5}c_{q6}+ \\
& c_{q3}s_{q4}s_{q6}c_{q4}{c_{q5}}^2+c_{q3}s_{q4}s_{q5}c_{q4}c_{q5}{c_{q6}}^2-\tfrac{1}{2}c_{q3}s_{q4}s_{q6}c_{q4}+\tfrac{3}{2}c_{q3}c_{q5}c_{q6}- \\
& s_{q3}s_{q4}s_{q5}s_{q6}c_{q5}\big)+\dot{q}_6\big(\tfrac{3}{2}c_{q5}s_{q3}s_{q6}+c_{q3}c_{q4}s_{q5}s_{q6}\big)+\dot{q}_4\big(2s_{q3}s_{q6}{c_{q5}}^2-s_{q3}s_{q6}+ \\
& 2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}+\tfrac{3}{2}c_{q3}c_{q6}s_{q4}s_{q5}\big)\big)p_{11}+\big(\dot{q}_6\big({c_{q6}}^2s_{q3}s_{q5}-\tfrac{1}{2}s_{q3}s_{q5}+\tfrac{1}{2}c_{q3}c_{q4}c_{q5}- \\
& c_{q3}c_{q4}c_{q5}{c_{q6}}^2-c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}s_{q6}\big)+\dot{q}_4\big(\tfrac{1}{2}c_{q3}c_{q4}{c_{q6}}^2+c_{q5}{c_{q6}}^2s_{q3}s_{q5}- \\
& c_{q3}c_{q4}{c_{q5}}^2{c_{q6}}^2+c_{q3}c_{q5}c_{q6}s_{q4}s_{q6}-\tfrac{1}{2}c_{q3}c_{q5}{c_{q6}}^2s_{q4}s_{q5}\big)-\dot{q}_3\big(c_{q3}s_{q5}s_{q6}{c_{q4}}^2c_{q6}+ \\
& \tfrac{1}{2}s_{q3}s_{q5}c_{q4}c_{q5}{c_{q6}}^2+s_{q3}s_{q4}{c_{q5}}^2{c_{q6}}^2-\tfrac{1}{2}s_{q3}s_{q4}{c_{q6}}^2-c_{q3}s_{q5}s_{q6}c_{q6}\big)-\dot{q}_1\big(s_{q3}s_{q5}c_{q4}c_{q6}+ \\
& s_{q4}s_{q5}s_{q6}{c_{q3}}^2c_{q4}c_{q6}-s_{q5}{c_{q3}}^2c_{q5}{c_{q6}}^2-s_{q5}c_{q3}{c_{q4}}^2c_{q5}{c_{q6}}^2-2s_{q3}c_{q3}c_{q4}c_{q5}{c_{q6}}^2+ \\
& s_{q3}c_{q3}c_{q4}{c_{q6}}^2+s_{q3}s_{q4}s_{q6}c_{q3}c_{q5}c_{q6}+s_{q5}c_{q5}{c_{q6}}^2\big)p_{12}+\big(\dot{q}_1\big(s_{q5}{c_{q3}}^2{c_{q4}}^2c_{q5}+ \\
& s_{q5}{c_{q3}}^2c_{q5}+s_{q3}c_{q3}c_{q4}{c_{q5}}^2-\tfrac{1}{2}s_{q3}c_{q3}c_{q4}-\tfrac{1}{2}s_{2q_5}\big)+\dot{q}_4\big(\tfrac{1}{2}c_{q3}c_{q4}-c_{q3}c_{q4}{c_{q5}}^2+ \\
& s_{q3}s_{q5}c_{q5}\big)-\dot{q}_3\big(s_{q3}s_{q4}{c_{q5}}^2+c_{q3}c_{q4}s_{q4}s_{q5}c_{q5}-\tfrac{1}{2}s_{q3}s_{q4}\big)p_{13}+\big(\dot{q}_3\big(-2c_{q3}s_{q5}{c_{q4}}^2{c_{q6}}^2+ \\
& s_{q3}c_{q4}c_{q5}{c_{q6}}^2-\tfrac{1}{2}s_{q3}c_{q4}c_{q5}c_{q6}+2s_{q3}s_{q4}s_{q6}{c_{q5}}^2c_{q6}+\tfrac{3}{2}c_{q3}s_{q5}{c_{q6}}^2-2s_{q3}s_{q4}s_{q6}c_{q6}\big)- \\
& \dot{q}_1\big(2s_{q5}s_{q6}{c_{q3}}^2{c_{q4}}^2c_{q5}c_{q6}+2s_{q4}s_{q5}{c_{q3}}^2c_{q4}{c_{q6}}^2+2s_{q5}s_{q6}{c_{q3}}^2c_{q5}c_{q6}+ \\
& 4s_{q3}s_{q6}c_{q3}c_{q4}{c_{q5}}^2c_{q6}-2s_{q3}s_{q6}c_{q3}c_{q4}c_{q6}+2s_{q3}s_{q4}c_{q3}c_{q5}{c_{q6}}^2-2s_{q5}s_{q6}c_{q5}c_{q6}\big)+ \\
& \dot{q}_4\big(4c_{q3}c_{q4}s_{q6}{c_{q5}}^2c_{q6}+3c_{q3}s_{q4}c_{q5}{c_{q6}}^2-4s_{q3}s_{q5}s_{q6}c_{q5}c_{q6}-c_{q3}c_{q4}s_{q6}c_{q6}- \\
& \dot{q}_6\big(c_{q3}s_{q4}-2c_{q3}{c_{q6}}^2s_{q4}+c_{q6}s_{q3}s_{q5}s_{q6}-2c_{q3}c_{q4}c_{q5}c_{q6}s_{q6}\big)\big)p_{14}+ \\
& \big(\dot{q}_3\big(c_{q3}{c_{q4}}^2c_{q5}s_{q6}-c_{q3}c_{q5}s_{q6}-c_{q3}c_{q4}c_{q6}s_{q4}-c_{q5}c_{q6}s_{q3}s_{q4}s_{q5}+ \\
& 2c_{q3}c_{q4}{c_{q5}}^2c_{q6}s_{q4}\big)-\dot{q}_6\big(c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q6}s_{q5}\big)+\dot{q}_1\big(s_{q6}{c_{q3}}^2{c_{q4}}^2{c_{q6}}^2- \\
& 2s_{q6}{c_{q3}}^2{c_{q4}}^2{c_{q5}}^2{c_{q6}}^2-2{c_{q3}}^2{c_{q4}}^2{c_{q5}}^2c_{q6}+2{c_{q5}}^2c_{q6}-c_{q6}+{c_{q3}}^2{c_{q4}}^2c_{q6}+ \\
& s_{q4}s_{q6}{c_{q3}}^2c_{q4}c_{q5}-2{c_{q3}}^2{c_{q5}}^2c_{q6}+{c_{q3}}^2c_{q6}+2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}c_{q6}- \\
& s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}\big)+\dot{q}_4\big(c_{q6}s_{q3}-2c_{q6}s_{q3}{c_{q5}}^2-c_{q3}c_{q4}c_{q6}s_{q5}c_{q5}+c_{q3}s_{q4}s_{q5}s_{q6}\big)+ \\
& \tfrac{1}{2}\dot{q}_2c_{q2}c_{q5}s_{q4}\big)p_{15}+\big(\dot{q}_1\big(2c_{q3}c_{q5}c_{q6}s_{q2}-2c_{q4}c_{q6}s_{q2}s_{q3}s_{q5}\big)-\dot{q}_2\big(\tfrac{1}{2}c_{q2}c_{q6}s_{q5}+ \\
& \tfrac{1}{2}c_{q2}c_{q6}s_{q4}s_{q5}\big)\big)p_{16}+\big(\dot{q}_1\big(2c_{q4}s_{q2}s_{q3}s_{q5}s_{q6}-c_{q3}c_{q5}s_{q2}s_{q6}+\big)\big)p_{17}+\big(\dot{q}_2c_{q2}c_{q5}s_{q4}+ \\
& \dot{q}_1c_{q3}s_{q2}s_{q5}\big)p_{18}+\big(\dot{q}_1\big(c_{q5}c_{q6}{c_{q3}}^2-c_{q4}c_{q6}s_{q3}s_{q5}c_{q3}+c_{q4}s_{q3}s_{q5}s_{q6}+ \\
& 2c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}s_{q5}\big)+\tfrac{1}{2}\dot{q}_3c_{q6}s_{q3}s_{q4}s_{q5}\big)p_{21}+\big(\dot{q}_1\big({c_{q3}}^2c_{q5}s_{q6}-c_{q3}c_{q4}s_{q3}s_{q5}s_{q6}\big)+ \\
& \dot{q}_3s_{q3}s_{q4}s_{q5}s_{q6}\big)p_{22}+\big(\dot{q}_1\big(s_{q5}{c_{q3}}^2+c_{q4}c_{q5}s_{q3}c_{q3}\big)-c_{q5}\dot{q}_3s_{q3}s_{q4}\big)p_{25}+ \\
& \big(\dot{q}_1\big(c_{q3}s_{q5}+c_{q4}c_{q5}s_{q3}\big)-\tfrac{1}{2}c_{q4}c_{q5}\dot{q}_4\big)p_{32}+\big(\dot{q}_3\big(c_{q3}s_{q5}-c_{q3}{c_{q4}}^2s_{q5}\big)+ \\
& \dot{q}_1\big(c_{q3}c_{q5}s_{q3}s_{q4}-{c_{q3}}^2c_{q4}s_{q4}s_{q5}\big)+c_{q3}c_{q5}\dot{q}_4s_{q4}\big)p_{33}+\big(\tfrac{1}{2}\dot{q}_4c_{q3}c_{q4}-\tfrac{1}{2}\dot{q}_3s_{q3}s_{q4}\big)p_{36}- \\
& \dot{q}_6\big(\tfrac{1}{2}s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}c_{q4}c_{q5}\big)p_{37}+\big(\dot{q}_4\big(4s_{q3}{c_{q5}}^2+2c_{q3}c_{q4}s_{q5}c_{q5}-2s_{q3}\big)+ \\
& \dot{q}_3\big(s_{q3}s_{q4}s_{q5}-4c_{q3}c_{q4}s_{q4}{c_{q5}}^2+2c_{q3}c_{q4}s_{q4}\big)-\dot{q}_1\big(4s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}-2{c_{q3}}^2{c_{q4}}^2{c_{q5}}^2+ \\
& {c_{q3}}^2{c_{q4}}^2-2{c_{q3}}^2{c_{q5}}^2+{c_{q3}}^2+2{c_{q5}}^2-1\big)p_{40}+\big(\dot{q}_3\big(c_{q3}c_{q5}-c_{q3}{c_{q4}}^2c_{q5}\big)+ \\
& \dot{q}_1\big(c_{q3}s_{q3}s_{q4}s_{q5}-2{c_{q3}}^2c_{q4}c_{q5}s_{q4}\big)-\dot{q}_4c_{q3}s_{q4}s_{q5}\big)p_{41}
\end{aligned}
\tag{B.98}
$$

$$C_{52} = \dot{q}_1\, c_{q2}\, c_{q5}\, s_{q4}\, p_{15} + \left(\dot{q}_6\, c_{q2}\, c_{q4}\, c_{q6}\, s_{q3}\, s_{q5} - \dot{q}_1\left(\tfrac{1}{2} c_{q2}\, c_{q6}\, s_{q5} + \tfrac{1}{2} c_{q2}\, c_{q6}\, s_{q4}\, s_{q5}\right) - \dot{q}_2\left(c_{q2}\, c_{q5}\, c_{q6}\, s_{q3} - c_{q3}\, c_{q5}\, c_{q6}\, s_{q2} + c_{q2}\, c_{q3}\, c_{q4}\, c_{q6}\, s_{q5} + c_{q4}\, c_{q6}\, s_{q2}\, s_{q3}\, s_{q5}\right) p_{16} + \dot{q}_3\left(\tfrac{1}{2} s_{q3}\, s_{q5} - \tfrac{1}{2} c_{q4}\, s_{q2}\, s_{q3}\, s_{q5}\, s_{q6}\right) + \dot{q}_2\left(c_{q2}\, c_{q5}\, s_{q3}\, s_{q6} - c_{q3}\, c_{q5}\, s_{q2}\, s_{q6} + c_{q2}\, c_{q3}\, c_{q4}\, s_{q5}\, s_{q6} + c_{q4}\, s_{q2}\, s_{q3}\, s_{q5}\, s_{q6}\right) - \tfrac{1}{2}\dot{q}_6\, c_{q2}\, c_{q4}\, c_{q6}\, s_{q3}\, s_{q5}\right) p_{17} + \left(-\dot{q}_3\left(\tfrac{1}{2} c_{q2}\, c_{q4}\, s_{q3}\, s_{q5} + \tfrac{1}{2} c_{q2}\, c_{q3}\, c_{q4}\, c_{q5}\right) + \dot{q}_4\left(\tfrac{1}{2} c_{q2}\, c_{q5}\, s_{q3}\, s_{q4} - \tfrac{1}{2} c_{q3}\, c_{q5}\, s_{q2}\, s_{q4}\right) + \dot{q}_2\left(c_{q3}\, s_{q2}\, s_{q5} - c_{q2}\, s_{q3}\, s_{q5} + c_{q4}\, c_{q5}\, s_{q2}\, s_{q3} + c_{q2}\, c_{q3}\, c_{q4}\, c_{q5}\right) + \dot{q}_1\, c_{q2}\, c_{q5}\, s_{q4}\right) p_{18} - \dot{q}_4\left(\tfrac{1}{2} c_{q2}\, c_{q5}\, s_{q3}\, s_{q4} - \tfrac{1}{2} c_{q3}\, c_{q5}\, s_{q2}\, s_{q4}\right) p_{38} \tag{B.99}$$

$$C_{53} = \left(\dot{q}_1\left(\tfrac{1}{2} c_{q6}\, s_{q3}\, s_{q4}\, s_{q5} - c_{q3}\, c_{q6}\, s_{q4}\, s_{q5}\right) - \dot{q}_3\, c_{q4}\, c_{q6}\, s_{q5}\right) p_5 + \left(2\dot{q}_3\, c_{q4}\, s_{q5}\, s_{q6} + \dot{q}_1\, c_{q3}\, s_{q4}\, s_{q5}\, s_{q6}\right) p_6 + \left(c_{q4}\, c_{q5}\, \dot{q}_3 + c_{q3}\, c_{q5}\, \dot{q}_1\, s_{q4}\right) p_7 + \dot{q}_3\left(2 s_{q6}\, {c_{q5}}^2 - 2 s_{q6}\, {c_{q4}}^2\, {c_{q5}}^2 + s_{q6}\, {c_{q4}}^2 - c_{q6}\, s_{q4}\, c_{q4}\, c_{q5} - s_{q6}\right) + \left(\dot{q}_1\left(c_{q3}\, s_{q4}\, s_{q5}\, c_{q4}\, c_{q5}\, {c_{q6}}^2 - c_{q3}\, {c_{q4}}^2\, c_{q5}\, c_{q6} + c_{q3}\, s_{q4}\, s_{q6}\, c_{q4}\, {c_{q5}}^2 - \tfrac{1}{2} c_{q3}\, s_{q4}\, s_{q6}\, c_{q4} + \tfrac{3}{2} c_{q3}\, c_{q5}\, c_{q6} - s_{q3}\, s_{q4}\, s_{q5}\, s_{q6}\, c_{q5}\right) + \dot{q}_4\left(c_{q4}\, c_{q6}\, s_{q5} - 2 c_{q5}\, s_{q4}\, s_{q5}\, s_{q6}\right) - \dot{q}_6\, s_{q4}\, s_{q5}\, s_{q6}\right) p_{11} + \left(\dot{q}_6\left(-c_{q5}\, s_{q4} + c_{q5}\, {c_{q6}}^2\, s_{q4}\right) + \dot{q}_3\left(c_{q5}\, s_{q5}\, {c_{q6}}^2 - c_{q5}\, s_{q5}\, {c_{q4}}^2\, {c_{q6}}^2 + s_{q4}\, s_{q5}\, s_{q6}\, c_{q4}\, c_{q6}\right) + \dot{q}_4\left(\tfrac{1}{2} s_{q4}\, {c_{q5}}^2 - s_{q4}\, {c_{q5}}^2\, {c_{q6}}^2 + c_{q4}\, s_{q6}\, c_{q5}\, c_{q6} + \tfrac{1}{2} s_{q4}\, {c_{q6}}^2\right) - \dot{q}_1\left(c_{q3}\, s_{q5}\, s_{q6}\, {c_{q4}}^2\, c_{q6} + \tfrac{1}{2} s_{q3}\, s_{q5}\, c_{q4}\, c_{q5}\, {c_{q6}}^2 + s_{q3}\, s_{q4}\, {c_{q5}}^2\, {c_{q6}}^2 - \tfrac{1}{2} s_{q3}\, s_{q4}\, {c_{q6}}^2 - c_{q3}\, s_{q5}\, s_{q6}\, c_{q6}\right)\right) p_{12} + \left(\dot{q}_4\left({c_{q5}}^2\, s_{q4} - \tfrac{1}{2} s_{q4}\right) + \dot{q}_3\left(\tfrac{1}{2} s_{2q_5} - {c_{q4}}^2\, c_{q5}\, s_{q5}\right) - \dot{q}_1\left(s_{q3}\, s_{q4}\, {c_{q5}}^2 + c_{q3}\, c_{q4}\, s_{q4}\, s_{q5}\, c_{q5} - \tfrac{1}{2} s_{q3}\, s_{q4}\right)\right) p_{13} + \left(\dot{q}_3\left(\tfrac{1}{2} s_{q5}\, s_{q6}\, {c_{q4}}^2\, c_{q6} + s_{q4}\, s_{q5}\, c_{q4}\, {c_{q6}}^2 - 2 c_{q5}\, s_{q5}\, s_{q6}\, c_{q6}\right) + \dot{q}_1\left(s_{q3}\, c_{q4}\, c_{q5}\, {c_{q6}}^2 - 2 c_{q3}\, s_{q5}\, {c_{q4}}^2\, {c_{q6}}^2 - \tfrac{1}{2} s_{q3}\, c_{q4}\, c_{q5}\, c_{q6} + 2 s_{q3}\, s_{q4}\, s_{q6}\, {c_{q5}}^2\, c_{q6} + \tfrac{3}{2} c_{q3}\, s_{q5}\, {c_{q6}}^2 - 2 s_{q3}\, s_{q4}\, s_{q6}\, c_{q6}\right) - \dot{q}_6\left(c_{q5}\, s_{q4}\, s_{q6}\, c_{q6} - c_{q4}\, {c_{q6}}^2 + \tfrac{1}{2} c_{q4}\right) + \dot{q}_4\left(c_{q4}\, c_{q5}\, {c_{q6}}^2 - {c_{q5}}^2\, c_{q6}\, s_{q4}\, s_{q6}\right) p_{14} - \left(\dot{q}_3\left(2 c_{q6}\, {c_{q4}}^2\, {c_{q5}}^2 - c_{q6}\, {c_{q4}}^2 + s_{q4}\, s_{q6}\, c_{q4}\, c_{q5} + 2 c_{q6}\, {c_{q5}}^2 - c_{q6}\right) + \left(\dot{q}_1\left(c_{q3}\, c_{q5}\, s_{q6} - c_{q3}\, {c_{q4}}^2\, c_{q5}\, s_{q6} + c_{q3}\, c_{q4}\, c_{q6}\, s_{q4} + c_{q5}\, c_{q6}\, s_{q3}\, s_{q4}\, s_{q5} - 2 c_{q3}\, c_{q4}\, {c_{q5}}^2\, c_{q6}\, s_{q4}\right) - \dot{q}_4\left(c_{q4}\, s_{q5}\, s_{q6} + c_{q5}\, c_{q6}\, s_{q4}\, s_{q5}\right) + \dot{q}_6\, c_{q6}\, s_{q4}\, s_{q5}\right) p_{15} + \dot{q}_2\left(\tfrac{1}{2} s_{q3}\, s_{q5} - \tfrac{1}{2} c_{q4}\, s_{q2}\, s_{q3}\, s_{q5}\, s_{q6}\right) p_{17} - \dot{q}_2\left(\tfrac{1}{2} c_{q2}\, c_{q4}\, s_{q3}\, s_{q5} + \tfrac{1}{2} c_{q2}\, c_{q3}\, c_{q4}\, c_{q5}\right) p_{18} + \left(c_{q5}\, c_{q6}\, \dot{q}_3 + \dot{q}_1\, c_{q6}\, s_{q3}\, s_{q4}\, s_{q5}\right) p_{21} + \left(c_{q4}\, c_{q6}\, \dot{q}_6\, s_{q5} - c_{q5}\, \dot{q}_3\, s_{q6} - \dot{q}_1\, s_{q3}\, s_{q4}\, s_{q5}\, s_{q6}\right) p_{22} + \left(\dot{q}_3\, s_{q5} - c_{q5}\, \dot{q}_1\, s_{q3}\, s_{q4}\right) p_{25} + \left(\dot{q}_1\left(c_{q3}\, s_{q5} - c_{q3}\, {c_{q4}}^2\, s_{q5}\right) + c_{q4}\, c_{q5}\, \dot{q}_4 + \dot{q}_3\, c_{q4}\, s_{q4}\, s_{q5}\right) p_{33} - \left(\tfrac{1}{2}\dot{q}_4\, s_{q4} + \tfrac{1}{2}\dot{q}_1\, s_{q3}\, s_{q4}\right) p_{36} - \tfrac{1}{2}\dot{q}_6\, c_{q5}\, s_{q4}\, p_{37} + \left(\dot{q}_1\left(s_{q3}\, s_{q4}\, s_{q5} - 4 c_{q3}\, c_{q4}\, s_{q4}\, {c_{q5}}^2 + 2 c_{q3}\, c_{q4}\, s_{q4}\right) + \dot{q}_3\left(-2 {c_{q4}}^2\, {c_{q5}}^2 + {c_{q4}}^2 + 4 {c_{q5}}^2 - 2\right) - 2\dot{q}_4\, c_{q5}\, s_{q4}\, s_{q5}\right) p_{40} + \left(\dot{q}_1\left(c_{q3}\, c_{q5} - c_{q3}\, {c_{q4}}^2\, c_{q5}\right) - c_{q4}\, \dot{q}_4\, s_{q5} + \dot{q}_3\, c_{q4}\, c_{q5}\, s_{q4}\right) p_{41} \tag{B.100}$$

$$C_{54} = \left(\dot{q}_4\left(s_{q6} - 2c_{q5}{}^2 s_{q6}\right) + \dot{q}_3\left(c_{q4}c_{q6}s_{q5} - 2c_{q5}s_{q4}s_{q5}s_{q6}\right) + \dot{q}_1 2s_{q3}s_{q6}c_{q5}{}^2 + 2c_{q3}c_{q4}s_{q5}s_{q6}c_{q5} - s_{q3}s_{q6} + \tfrac{3}{2}c_{q3}c_{q6}s_{q4}s_{q5} - \dot{q}_6 c_{q5}s_{q6}\right)p_{11} + \left(\dot{q}_1\left(\tfrac{1}{2}c_{q3}c_{q4}c_{q6}{}^2 + c_{q5}c_{q6}{}^2 s_{q3}s_{q5} - c_{q3}c_{q4}c_{q5}{}^2 c_{q6}{}^2 + c_{q3}c_{q5}c_{q6}s_{q4}s_{q6} - \tfrac{1}{2}c_{q3}c_{q5}c_{q6}{}^2 s_{q4}s_{q5}\right) + \dot{q}_6\left(\tfrac{1}{2}s_{q5} - c_{q6}{}^2 s_{q5}\right) + \dot{q}_3\left(s_{q4}c_{q6}{}^2 - s_{q4}c_{q5}{}^2 c_{q6}{}^2 + \tfrac{1}{2}s_{q4}c_{q5}{}^2 + c_{q4}s_{q6}c_{q5}c_{q6}\right) - \dot{q}_4 c_{q5}c_{q6}{}^2 s_{q5}\right)p_{12} + \left(\dot{q}_1\left(\tfrac{1}{2}c_{q3}c_{q4} - c_{q3}c_{q4}c_{q5}{}^2 + s_{q3}s_{q5}c_{q5}\right) - \dot{q}_4\sin(2q_5) - \dot{q}_3\left(\tfrac{1}{2}s_{q4} - c_{q5}{}^2 s_{q4}\right)\right)p_{13} + \left(\dot{q}_3\left(c_{q4}c_{q5}c_{q6}{}^2 - c_{q5}{}^2 c_{q6}s_{q4}s_{q6}\right) + \dot{q}_1\left(4c_{q3}c_{q4}s_{q6}c_{q5}{}^2 c_{q6} + 3c_{q3}s_{q4}c_{q5}c_{q6}{}^2 - 4s_{q3}s_{q5}s_{q6}c_{q5}c_{q6} - c_{q3}c_{q4}s_{q6}c_{q6}\right) + \dot{q}_6 c_{q6}s_{q5}s_{q6} + \dot{q}_4 c_{q5}c_{q6}s_{q5}s_{q6}\right)p_{14} + \dot{q}_4\left(c_{q6} - 2c_{q5}{}^2 c_{q6}\right) + \dot{q}_6\left(2c_{q6}c_{q3}{}^2 c_{q5}{}^2 - c_{q6}c_{q3}{}^2 + c_{q6}c_{q5}\right) + \dot{q}_1\left(c_{q3}s_{q4}s_{q5}s_{q6} - 2c_{q6}s_{q3}c_{q5}{}^2 - c_{q3}c_{q4}c_{q6}s_{q5}c_{q5} + c_{q6}s_{q3}\right) + \dot{q}_3\left(c_{q4}s_{q5}s_{q6} + c_{q5}c_{q6}s_{q4}s_{q5}\right)\right)p_{15} + \dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q5}s_{q3}s_{q4} - \tfrac{1}{2}c_{q3}c_{q5}s_{q2}s_{q4}\right)p_{18} - \dot{q}_1 c_{q4}c_{q5}p_{32} + \left(c_{q4}c_{q5}\dot{q}_3 + c_{q3}c_{q5}\dot{q}_1 s_{q4}\right)p_{33} + \left(\tfrac{1}{2}c_{q3}c_{q4}\dot{q}_1 - \tfrac{1}{2}\dot{q}_3 s_{q4}\right)p_{36} - \dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q5}s_{q3}s_{q4} - \tfrac{1}{2}c_{q3}c_{q5}s_{q2}s_{q4}\right)p_{38} - \left(\dot{q}_4\left(2c_{q5}{}^2 - 1\right) + \dot{q}_1\left(4s_{q3}c_{q5}{}^2 + 2c_{q3}c_{q4}s_{q5}c_{q5} - 2s_{q3}\right) - 2\dot{q}_3 c_{q5}s_{q4}s_{q5}\right)p_{40} - \left(c_{q4}\dot{q}_3 s_{q5} + c_{q3}\dot{q}_1 s_{q4}s_{q5}\right)p_{41} \tag{B.101}$$

$$C_{55} = \tfrac{1}{2}\dot{q}_6 s_{2q_6}\, p_{12} + \dot{q}_6 c_{2q_6}\, p_{14} \tag{B.102}$$

$$C_{56} = \left(\dot{q}_1\left(\tfrac{3}{2}c_{q5}s_{q3}s_{q6} + c_{q3}c_{q4}s_{q5}s_{q6}\right) - \dot{q}_6 s_{q6} - c_{q5}\dot{q}_4 s_{q6} - \dot{q}_3 s_{q4}s_{q5}s_{q6}\right)p_{11} + \left(\tfrac{1}{2}\dot{q}_5 s_{2q_6} - \dot{q}_1\left(\tfrac{1}{2}s_{q3}s_{q5} - c_{q6}{}^2 s_{q3}s_{q5} - \tfrac{1}{2}c_{q3}c_{q4}c_{q5} + c_{q3}c_{q4}c_{q5}c_{q6}{}^2 + c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}s_{q6}\right) - \dot{q}_3\left(\tfrac{1}{2}c_{q5}s_{q4} - c_{q5}c_{q6}{}^2 s_{q4}\right) + \dot{q}_4\left(\tfrac{1}{2}s_{q5} - c_{q6}{}^2 s_{q5}\right)\right)p_{12} + \left(\dot{q}_5\left(2c_{q6}{}^2 - 1\right) - \dot{q}_3\left(\tfrac{1}{2}c_{q4} - c_{q4}c_{q6}{}^2 + c_{q5}s_{q4}s_{q6}c_{q6}\right) - \dot{q}_1\left(c_{q3}s_{q4} - 2c_{q3}c_{q6}{}^2 s_{q4} + c_{q6}s_{q3}s_{q5}s_{q6} - 2c_{q3}c_{q4}c_{q5}c_{q6}s_{q6}\right) + \dot{q}_4 c_{q6}s_{q5}s_{q6}\right)p_{14} + \left(\dot{q}_4\left(2c_{q6}c_{q3}{}^2 c_{q5}{}^2 - c_{q6}c_{q3}{}^2 + c_{q6}c_{q5}\right) + c_{q6}\dot{q}_6 - \dot{q}_1\left(c_{q5}c_{q6}s_{q3} + c_{q3}c_{q4}c_{q6}s_{q5}\right) + \dot{q}_3 c_{q6}s_{q4}s_{q5}\right)p_{15} + \dot{q}_2 c_{q2}c_{q4}c_{q6}s_{q3}s_{q5}\, p_{16} - \dot{q}_2 c_{q2}c_{q4}c_{q6}s_{q3}s_{q5}\, p_{17} + c_{q4}c_{q6}\dot{q}_3 s_{q5}\, p_{22} - \left(\dot{q}_1\left(\tfrac{1}{2}s_{q3}s_{q5} - \tfrac{1}{2}c_{q3}c_{q4}c_{q5}\right) + \tfrac{1}{2}c_{q5}s_{q4}\dot{q}_3\right)p_{37} \tag{B.103}$$

$$
\begin{aligned}
C_{61} = {} & \left(\dot{q}_3\left(c_{q3}c_{q4}c_{q6}-c_{q3}c_{q5}s_{q4}s_{q6}+\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\right)-\dot{q}_1\left(c_{q6}s_{q4}+c_{q4}c_{q5}s_{q6}+\right.\right.\\
& c_{q3}s_{q5}s_{q6}-c_{q3}{}^2c_{q6}s_{q4}+c_{q3}c_{q6}s_{q3}s_{q5}+c_{q3}s_{q3}s_{q5}s_{q6}\left.\right)-\dot{q}_4\left(\tfrac{1}{2}c_{q6}s_{q3}s_{q4}+\right.\\
& \left.\left.\tfrac{1}{2}s_{q3}s_{q4}s_{q6}\right)\right)p_5-\left(\dot{q}_3\left(c_{q3}c_{q4}s_{q6}+c_{q3}c_{q5}c_{q6}s_{q4}\right)+\dot{q}_1\left(2c_{q3}{}^2s_{q4}s_{q6}-2s_{q4}s_{q6}+\right.\right.\\
& \left.\left.c_{q4}c_{q5}c_{q6}+2c_{q3}c_{q6}s_{q5}-2c_{q3}{}^2c_{q4}c_{q5}c_{q6}\right)\right)p_6-\left(\dot{q}_3\left(c_{q4}c_{q5}s_{q3}s_{q6}+\right.\right.\\
& c_{q3}c_{q4}{}^2s_{q5}s_{q6}+\tfrac{1}{2}c_{q5}{}^2c_{q6}s_{q3}s_{q4}+c_{q3}c_{q4}c_{q5}{}^2c_{q6}s_{q4}s_{q6}+\tfrac{1}{2}c_{q3}c_{q4}c_{q5}c_{q6}s_{q4}s_{q5}\left.\right)-\\
& \dot{q}_4\left(c_{q3}c_{q4}c_{q6}+\tfrac{1}{2}c_{q3}c_{q5}s_{q4}s_{q6}+c_{q5}c_{q6}s_{q3}s_{q5}-c_{q3}c_{q4}c_{q5}{}^2c_{q6}\right)+\\
& \dot{q}_1\left(\tfrac{1}{2}s_{q4}s_{q5}s_{q6}c_{q3}{}^2c_{q4}-\tfrac{1}{2}c_{q6}s_{q5}c_{q3}{}^2c_{q4}{}^2c_{q5}-c_{q6}s_{q5}c_{q3}{}^2c_{q5}-\right.\\
& 2c_{q6}s_{q3}c_{q3}c_{q4}c_{q5}{}^2+\tfrac{1}{2}c_{q6}s_{q3}c_{q3}c_{q4}+s_{q3}s_{q4}s_{q6}c_{q3}c_{q5}+\tfrac{1}{2}c_{q6}s_{q5}c_{q5}+\\
& \left.\dot{q}_5\tfrac{3}{2}c_{q5}s_{q3}s_{q6}+c_{q3}c_{q4}s_{q5}s_{q6}\right)\Big)p_{11}+\left(\dot{q}_1\left(s_{q6}c_{q3}{}^2c_{q4}{}^2c_{q6}+2s_{q4}c_{q3}{}^2c_{q4}c_{q5}c_{q6}{}^2-\right.\right.\\
& s_{q4}c_{q3}{}^2c_{q4}c_{q5}+s_{q6}c_{q3}{}^2c_{q5}{}^2c_{q6}-2s_{q6}c_{q3}{}^2c_{q6}+s_{q6}c_{q3}c_{q4}{}^2c_{q5}{}^2c_{q6}-\\
& 2s_{q3}s_{q5}s_{q6}c_{q3}c_{q4}c_{q5}c_{q6}-2s_{q3}s_{q4}s_{q5}c_{q3}c_{q6}{}^2+s_{q3}s_{q4}s_{q5}c_{q3}-s_{q3}s_{q6}c_{q4}c_{q5}-\\
& s_{q6}c_{q5}{}^2c_{q6}+\tfrac{1}{2}s_{2q_6}\left.\right)+\dot{q}_5\left(\tfrac{1}{2}s_{q3}s_{q5}-c_{q6}{}^2s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}c_{q4}c_{q5}+c_{q3}c_{q4}c_{q5}c_{q6}{}^2+\right.\\
& \left.c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}s_{q6}\right)+\dot{q}_4\left(s_{q3}s_{q6}c_{q5}{}^2c_{q6}+c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6}+c_{q3}s_{q4}s_{q5}c_{q6}{}^2-\right.\\
& s_{q3}s_{q6}c_{q6}-\tfrac{1}{2}c_{q3}s_{q4}s_{q5}+\dot{q}_3\left(2c_{q3}c_{q5}c_{q4}{}^2c_{q6}{}^2-c_{q3}c_{q5}c_{q4}{}^2-s_{q3}s_{q5}c_{q4}c_{q6}{}^2-\right.\\
& c_{q3}s_{q4}s_{q6}c_{q4}c_{q6}+\tfrac{1}{2}s_{q3}s_{q5}c_{q4}-c_{q3}c_{q5}c_{q6}{}^2+c_{q5}s_{q3}s_{q4}s_{q5}s_{q6}c_{q6}+\\
& \left.\left.\tfrac{1}{2}c_{q3}c_{q5}\right)\right)p_{12}-\tfrac{1}{2}\dot{q}_4s_{2q_6}p_{13}+\left(\dot{q}_1\left(2c_{q3}{}^2c_{q4}{}^2c_{q5}{}^2c_{q6}{}^2-c_{q3}{}^2c_{q4}{}^2c_{q5}{}^2-\right.\right.\\
& 4s_{q4}s_{q6}c_{q3}{}^2c_{q4}c_{q5}c_{q6}+2c_{q3}{}^2c_{q5}{}^2c_{q6}{}^2-c_{q3}{}^2c_{q5}{}^2-4c_{q3}{}^2c_{q6}{}^2+2c_{q3}{}^2-\\
& 4s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}c_{q6}{}^2+2s_{q3}s_{q5}c_{q3}c_{q4}c_{q5}+4s_{q3}s_{q4}s_{q5}s_{q6}c_{q3}c_{q6}-2c_{q5}{}^2c_{q6}{}^2+\\
& \left.c_{q5}{}^2+2c_{q6}{}^2-1\right)-\left(\dot{q}_4\left(2s_{q3}c_{q5}{}^2-4s_{q3}c_{q5}{}^2c_{q6}{}^2-4c_{q3}c_{q4}s_{q5}c_{q5}c_{q6}{}^2+\right.\right.\\
& 2c_{q3}c_{q4}s_{q5}c_{q5}+4s_{q3}c_{q6}{}^2+4c_{q3}s_{q4}s_{q5}s_{q6}c_{q6}-2s_{q3}\left.\right)+\dot{q}_5\left(c_{q3}s_{q4}-2c_{q3}c_{q6}{}^2s_{q4}+\right.\\
& c_{q6}s_{q3}s_{q5}s_{q6}-2c_{q3}c_{q4}c_{q5}c_{q6}s_{q6}\left.\right)+\dot{q}_3\left(\tfrac{3}{2}c_{q3}c_{q4}s_{q4}-c_{q5}s_{q3}s_{q4}s_{q5}+c_{q4}s_{q3}s_{q5}s_{q6}-\right.\\
& \left.\left.3c_{q3}c_{q4}c_{q6}{}^2s_{q4}+2c_{q3}c_{q5}c_{q6}s_{q6}-4c_{q3}c_{q4}{}^2c_{q5}c_{q6}s_{q6}+2c_{q5}c_{q6}{}^2s_{q3}s_{q4}s_{q5}\right)\right)p_{14}+\\
& \left(\dot{q}_1\left(2s_{q5}c_{q3}{}^2c_{q4}{}^2c_{q5}c_{q6}-3s_{q5}c_{q3}{}^2c_{q4}{}^2c_{q5}c_{q6}{}^3+s_{q5}s_{q6}c_{q3}{}^2c_{q4}{}^2c_{q5}+s_{q4}s_{q5}c_{q3}{}^2c_{q4}c_{q6}+\right.\right.\\
& s_{q5}s_{q6}c_{q3}{}^2c_{q5}+s_{q3}s_{q6}c_{q3}c_{q4}c_{q5}{}^2+s_{q3}s_{q4}c_{q3}c_{q5}c_{q6}-s_{q5}s_{q6}c_{q5}\left.\right)+\\
& \dot{q}_4\left(\tfrac{1}{2}c_{q3}c_{q4}s_{q6}-c_{q3}c_{q4}s_{q6}c_{q5}{}^2+s_{q3}s_{q5}s_{q6}c_{q5}\right)-\dot{q}_3\left(s_{q3}s_{q4}s_{q6}-c_{q3}c_{q4}{}^2c_{q6}s_{q5}+\right.\\
& \tfrac{1}{2}c_{q5}{}^2s_{q3}s_{q4}s_{q6}-c_{q4}c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q5}s_{q4}s_{q5}s_{q6}\left.\right)+\\
& \dot{q}_5\left(c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q6}s_{q5}\right)\Big)p_{15}-\left(\dot{q}_2\left(\tfrac{1}{2}c_{q2}c_{q5}s_{q6}-c_{q2}c_{q4}c_{q6}+\tfrac{1}{2}c_{q2}c_{q5}s_{q4}s_{q6}\right)+\right.\\
& \dot{q}_1\left(c_{q6}s_{q2}s_{q3}s_{q4}+2c_{q3}s_{q2}s_{q5}s_{q6}+2c_{q4}c_{q5}s_{q2}s_{q3}s_{q6}\right)p_{16}-\\
& \left(\dot{q}_1\left(c_{q3}c_{q6}s_{q2}s_{q5}-2s_{q2}s_{q4}s_{q6}+2c_{q4}c_{q5}c_{q6}s_{q2}s_{q3}\right)+\dot{q}_2c_{q2}c_{q4}s_{q6}\right)p_{17}-\\
& \left(\dot{q}_1\left(s_{q5}s_{q6}c_{q3}{}^2+c_{q4}s_{q3}s_{q6}c_{q3}c_{q5}+c_{q6}s_{q3}s_{q4}c_{q3}-c_{q4}s_{q2}s_{q3}s_{q6}c_{q5}{}^2+c_{q4}c_{q6}s_{q3}c_{q5}+\right.\right.\\
& c_{q4}s_{q2}s_{q3}s_{q6}\left.\right)+\dot{q}_3\left(c_{q4}c_{q6}s_{q3}-\tfrac{1}{2}c_{q5}s_{q3}s_{q4}s_{q6}\right)\Big)p_{21}+\left(\dot{q}_3\left(c_{q4}s_{q3}s_{q6}+c_{q5}c_{q6}s_{q3}s_{q4}\right)-\right.\\
& \left.\left.\dot{q}_1\left(c_{q3}{}^2c_{q6}s_{q5}-c_{q3}s_{q3}s_{q4}s_{q6}+c_{q3}c_{q4}c_{q5}c_{q6}s_{q3}\right)\right)p_{22}-\right.\\
& c_{q6}\dot{q}_1s_{q3}s_{q4}\,p_{23}+\left(\dot{q}_1s_{q3}s_{q4}s_{q6}-\dot{q}_4\left(\tfrac{1}{2}c_{q4}c_{q6}-\tfrac{1}{2}s_{q4}s_{q6}\right)\right)p_{24}+\\
& \left(\dot{q}_5\left(\tfrac{1}{2}s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}c_{q4}c_{q5}\right)-\dot{q}_3\left(\tfrac{1}{2}c_{q3}c_{q5}-\tfrac{1}{2}c_{q4}s_{q3}s_{q5}\right)+\tfrac{1}{2}\dot{q}_4c_{q3}s_{q4}s_{q5}\right)p_{37}
\end{aligned}
\tag{B.104}
$$

$$
\begin{aligned}
C_{62} = {} & \big(\dot{q}_1\big(\mathrm{C}_{q2}\mathrm{C}_{q4}\mathrm{C}_{q6}-\tfrac{1}{2}\mathrm{C}_{q2}\mathrm{C}_{q5}\mathrm{S}_{q6}-\tfrac{1}{2}\mathrm{C}_{q2}\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q6}\big)-\dot{q}_2\big(\mathrm{C}_{q6}\mathrm{S}_{q2}\mathrm{S}_{q3}\mathrm{S}_{q4}- \\
& \mathrm{C}_{q2}\mathrm{S}_{q3}\mathrm{S}_{q5}\mathrm{S}_{q6}+\mathrm{C}_{q3}\mathrm{S}_{q2}\mathrm{S}_{q5}\mathrm{S}_{q6}+\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q6}\mathrm{S}_{q4}+\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{S}_{q6}+ \\
& \mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q2}\mathrm{S}_{q3}+\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{S}_{q2}\mathrm{S}_{q3}\mathrm{S}_{q6}\big)+\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\dot{q}_3- \\
& \tfrac{1}{2}\mathrm{C}_{q2}\mathrm{C}_{q5}\mathrm{C}_{q6}\dot{q}_4\mathrm{S}_{q3}\mathrm{S}_{q4}-\tfrac{1}{2}\mathrm{C}_{q2}\mathrm{C}_{q4}\mathrm{C}_{q6}\dot{q}_5\mathrm{S}_{q3}\mathrm{S}_{q5}\big)p_{16}+ \\
& \dot{q}_2\big(\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}+\mathrm{C}_{q2}\mathrm{C}_{q6}\mathrm{S}_{q3}\mathrm{S}_{q5}-\mathrm{C}_{q3}\mathrm{C}_{q6}\mathrm{S}_{q2}\mathrm{S}_{q5}+\mathrm{S}_{q2}\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}- \\
& \mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\big)-\dot{q}_3\big(\tfrac{1}{2}\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}-\tfrac{1}{2}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q2}\mathrm{S}_{q3}\big)- \\
& \dot{q}_1\mathrm{C}_{q2}\mathrm{C}_{q4}\mathrm{S}_{q6}+\tfrac{1}{2}\dot{q}_4\mathrm{C}_{q2}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q3}\mathrm{S}_{q4}+\tfrac{1}{2}\dot{q}_5\mathrm{C}_{q2}\mathrm{C}_{q4}\mathrm{C}_{q6}\mathrm{S}_{q3}\mathrm{S}_{q5}\big)p_{17}
\end{aligned}
\tag{B.105}
$$

$$
\begin{aligned}
C_{63} = {} & \big(\dot{q}_1\big(\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q6}-\mathrm{C}_{q3}\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q6}+\tfrac{1}{2}\mathrm{C}_{q5}\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}\big)-\dot{q}_3\big(\mathrm{C}_{q6}\mathrm{S}_{q4}+\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{S}_{q6}\big)\big)p_5+ \\
& \big(\dot{q}_3\big(\mathrm{S}_{q4}\mathrm{S}_{q6}-2\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\big)-\dot{q}_1\big(\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{S}_{q6}+\mathrm{C}_{q3}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q4}\big)\big)p_6+ \\
& \big(\dot{q}_1\big(-\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{S}_{q3}\mathrm{S}_{q6}-\mathrm{C}_{q3}\mathrm{C}_{q4}{}^2\mathrm{S}_{q5}\mathrm{S}_{q6}-\tfrac{1}{2}\mathrm{C}_{q5}{}^2\mathrm{C}_{q6}\mathrm{S}_{q3}\mathrm{S}_{q4}-\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}{}^2\mathrm{C}_{q6}\mathrm{S}_{q4}\mathrm{S}_{q6}- \\
& \tfrac{1}{2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q4}\mathrm{S}_{q5}\big)+\dot{q}_3\big(-\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q5}\mathrm{C}_{q4}{}^2+\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{S}_{q6}\mathrm{C}_{q4}+\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q5}\big)- \\
& \dot{q}_4\big(\mathrm{C}_{q6}\mathrm{S}_{q4}-\mathrm{C}_{q5}{}^2\mathrm{C}_{q6}\mathrm{S}_{q4}\big)+\dot{q}_5\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{S}_{q6}\big)p_{11}+\big(\dot{q}_1\big(2\mathrm{C}_{q3}\mathrm{C}_{q5}\mathrm{C}_{q4}{}^2\mathrm{C}_{q6}{}^2-\mathrm{C}_{q3}\mathrm{C}_{q5}\mathrm{C}_{q4}{}^2- \\
& \mathrm{S}_{q3}\mathrm{S}_{q5}\mathrm{C}_{q4}\mathrm{C}_{q6}{}^2-\mathrm{C}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}\mathrm{C}_{q4}\mathrm{C}_{q6}+\tfrac{1}{2}\mathrm{S}_{q3}\mathrm{S}_{q5}\mathrm{C}_{q4}-\mathrm{C}_{q3}\mathrm{C}_{q5}\mathrm{C}_{q6}{}^2+\mathrm{C}_{q5}\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{S}_{q6}\mathrm{C}_{q6}+ \\
& \tfrac{1}{2}\mathrm{C}_{q3}\mathrm{C}_{q5}+\dot{q}_5\big(\tfrac{1}{2}\mathrm{C}_{q5}\mathrm{S}_{q4}-\mathrm{C}_{q5}\mathrm{C}_{q6}{}^2\mathrm{S}_{q4}\big)-\dot{q}_3\big(\mathrm{S}_{q6}\mathrm{C}_{q4}{}^2\mathrm{C}_{q5}{}^2\mathrm{C}_{q6}+\mathrm{S}_{q6}\mathrm{C}_{q4}{}^2\mathrm{C}_{q6}+ \\
& 2\mathrm{S}_{q4}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}{}^2-\mathrm{S}_{q4}\mathrm{C}_{q4}\mathrm{C}_{q5}-\mathrm{S}_{q6}\mathrm{C}_{q5}{}^2\mathrm{C}_{q6}+\dot{q}_4\big(\mathrm{C}_{q4}\mathrm{S}_{q5}\mathrm{C}_{q6}{}^2+\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{S}_{q6}\mathrm{C}_{q6}- \\
& \tfrac{1}{2}\mathrm{C}_{q4}\mathrm{S}_{q5}\big)p_{12}+\big(\dot{q}_4\big(\tfrac{1}{2}\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q5}-\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{C}_{q6}{}^2-\mathrm{C}_{q4}\mathrm{S}_{q5}\mathrm{S}_{q6}\mathrm{C}_{q6}\big)+\dot{q}_3\big(\tfrac{1}{2}\mathrm{C}_{q4}{}^2\mathrm{C}_{q5}- \\
& \mathrm{C}_{q4}{}^2\mathrm{C}_{q5}\mathrm{C}_{q6}{}^2-\mathrm{C}_{q4}{}^2\mathrm{C}_{q6}{}^2+\tfrac{1}{2}\mathrm{C}_{q4}{}^2+2\mathrm{S}_{q4}\mathrm{S}_{q6}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}+2\mathrm{C}_{q5}{}^2\mathrm{C}_{q6}{}^2-\mathrm{C}_{q5}{}^2\big)+ \\
& \dot{q}_5\big(\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q6}\mathrm{C}_{q6}-\mathrm{C}_{q4}\mathrm{C}_{q6}{}^2+\tfrac{1}{2}\mathrm{C}_{q4}\big)+\dot{q}_1\big(\tfrac{3}{2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{S}_{q4}-\mathrm{C}_{q5}\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q5}+ \\
& \tfrac{1}{2}\mathrm{C}_{q4}\mathrm{S}_{q3}\mathrm{S}_{q5}\mathrm{S}_{q6}-3\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q6}{}^2\mathrm{S}_{q4}+2\mathrm{C}_{q3}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q6}-4\mathrm{C}_{q3}\mathrm{C}_{q4}{}^2\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q6}+ \\
& 2\mathrm{C}_{q5}\mathrm{C}_{q6}{}^2\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q5}\big)p_{14}+\big(\dot{q}_3\big(\mathrm{C}_{q5}\mathrm{S}_{q5}\mathrm{S}_{q6}\mathrm{C}_{q4}{}^2-\mathrm{C}_{q6}\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{C}_{q4}+\mathrm{C}_{q5}\mathrm{S}_{q5}\mathrm{S}_{q6}\big)- \\
& \big(\dot{q}_1\big(\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}-\mathrm{C}_{q3}\mathrm{C}_{q4}{}^2\mathrm{C}_{q6}\mathrm{S}_{q5}+\tfrac{1}{2}\mathrm{C}_{q5}{}^2\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}-\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q3}+ \\
& \mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{S}_{q4}\mathrm{S}_{q5}\mathrm{S}_{q6}\big)+\dot{q}_4\big(\tfrac{1}{2}\mathrm{S}_{q4}\mathrm{S}_{q6}\mathrm{C}_{q5}{}^2+2\mathrm{C}_{q3}\mathrm{C}_{q6}\mathrm{S}_{q3}\mathrm{S}_{q5}\mathrm{C}_{q5}-\mathrm{S}_{q4}\mathrm{S}_{q6}\big)- \\
& \dot{q}_5\mathrm{C}_{q6}\mathrm{S}_{q4}\mathrm{S}_{q5}\big)p_{15}+\tfrac{1}{2}\dot{q}_2\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\,p_{16}+\dot{q}_2\big(\tfrac{1}{2}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q2}\mathrm{S}_{q3} \\
& -\tfrac{1}{2}\mathrm{C}_{q2}\mathrm{C}_{q3}\mathrm{C}_{q4}\mathrm{C}_{q5}\mathrm{C}_{q6}\big)p_{17}+\big(-\dot{q}_1\big(\mathrm{C}_{q5}\mathrm{S}_{q3}\mathrm{S}_{q4}\mathrm{S}_{q6}-\mathrm{C}_{q4}\mathrm{C}_{q6}\mathrm{S}_{q3}\big)- \\
& \dot{q}_3\mathrm{S}_{q5}\mathrm{S}_{q6}\big)p_{21}+\big(\dot{q}_1\big(\mathrm{C}_{q4}\mathrm{S}_{q3}\mathrm{S}_{q6}+\mathrm{C}_{q5}\mathrm{C}_{q6}\mathrm{S}_{q3}\mathrm{S}_{q4}\big)-\mathrm{C}_{q6}\dot{q}_3\mathrm{S}_{q5}-\mathrm{C}_{q5}\mathrm{C}_{q6}\dot{q}_4\mathrm{S}_{q4}- \\
& \dot{q}_5\mathrm{C}_{q4}\mathrm{C}_{q6}\mathrm{S}_{q5}\big)p_{22}+\big(\dot{q}_4\mathrm{C}_{q4}\mathrm{S}_{q5}-\dot{q}_1\big(\mathrm{C}_{q3}\mathrm{C}_{q5}-\mathrm{C}_{q4}\mathrm{S}_{q3}\mathrm{S}_{q5}\big)+\dot{q}_5\mathrm{C}_{q5}\mathrm{S}_{q4}\big)p_{37}
\end{aligned}
\tag{B.106}
$$

$$C_{64} = \left(-\dot{q}_1\left(\tfrac{1}{2}c_{q6}s_{q3}s_{q4}+\tfrac{1}{2}s_{q3}s_{q4}s_{q6}\right)\right)p_5+\left(\dot{q}_1\left(c_{q3}c_{q4}c_{q6}+\tfrac{1}{2}c_{q3}c_{q5}s_{q4}s_{q6}+\right.\right.$$
$$c_{q5}c_{q6}s_{q3}s_{q5}-c_{q3}c_{q4}{c_{q5}}^2c_{q6}\left.\right)-\dot{q}_3\left(c_{q6}s_{q4}-{c_{q5}}^2c_{q6}s_{q4}\right)+\dot{q}_5c_{q5}s_{q6}-$$
$$\dot{q}_4c_{q5}c_{q6}s_{q5}\left.\right)p_{11}+\left(\dot{q}_1\left(s_{q3}s_{q6}{c_{q5}}^2c_{q6}+c_{q3}c_{q4}s_{q5}s_{q6}c_{q5}c_{q6}+c_{q3}s_{q4}s_{q5}{c_{q6}}^2-\right.\right.$$
$$s_{q3}s_{q6}c_{q6}-\tfrac{1}{2}c_{q3}s_{q4}s_{q5}\left.\right)-\dot{q}_5\left(\tfrac{1}{2}s_{q5}-{c_{q6}}^2s_{q5}\right)+\dot{q}_4\left(\tfrac{1}{2}s_{2q_6}-{c_{q5}}^2c_{q6}s_{q6}\right)+$$
$$\left.\dot{q}_3\left(c_{q4}s_{q5}{c_{q6}}^2+c_{q5}s_{q4}s_{q5}s_{q6}c_{q6}-\tfrac{1}{2}c_{q4}s_{q5}\right)\right)p_{12}-\tfrac{1}{2}\dot{q}_1s_{2q_6}\,p_{13}-$$
$$\left(\dot{q}_3\left(\tfrac{1}{2}c_{q5}s_{q4}s_{q5}-c_{q5}s_{q4}s_{q5}{c_{q6}}^2-c_{q4}s_{q5}s_{q6}c_{q6}\right)+\right.$$
$$\dot{q}_4\left(-{c_{q5}}^2{c_{q6}}^2+\tfrac{1}{2}{c_{q5}}^2+2{c_{q6}}^2-1\right)-\dot{q}_1\left(2s_{q3}{c_{q5}}^2-4s_{q3}{c_{q5}}^2{c_{q6}}^2-\right.$$
$$4c_{q3}c_{q4}s_{q5}c_{q5}{c_{q6}}^2+2c_{q3}c_{q4}s_{q5}c_{q5}+4s_{q3}{c_{q6}}^2+4c_{q3}s_{q4}s_{q5}s_{q6}c_{q6}-2s_{q3}\left.\right)-$$
$$\dot{q}_5c_{q6}s_{q5}s_{q6}\left.\right)p_{14}+\left(\dot{q}_5\left(c_{q6}{c_{q3}}^2-2c_{q6}{c_{q3}}^2{c_{q5}}^2-c_{q6}c_{q5}\right)+\right.$$
$$\dot{q}_1\left(\tfrac{1}{2}c_{q3}c_{q4}s_{q6}-\tfrac{1}{2}c_{q3}c_{q4}s_{q6}{c_{q5}}^2+s_{q3}s_{q5}s_{q6}c_{q5}+\right)+$$
$$\left.\dot{q}_3\left(\tfrac{1}{2}s_{q4}s_{q6}{c_{q5}}^2+2c_{q3}c_{q6}s_{q3}s_{q5}c_{q5}-s_{q4}s_{q6}\right)+\dot{q}_4c_{q5}s_{q5}s_{q6}\right)p_{15}-$$
$$\tfrac{1}{2}\dot{q}_2c_{q2}c_{q5}c_{q6}s_{q3}s_{q4}p_{16}+\tfrac{1}{2}\dot{q}_2c_{q2}c_{q5}c_{q6}s_{q3}s_{q4}p_{17}-c_{q5}c_{q6}\dot{q}_3s_{q4}\,p_{22}-$$
$$\dot{q}_1\left(\tfrac{1}{2}c_{q4}c_{q6}-\tfrac{1}{2}s_{q4}s_{q6}\right)p_{24}+\left(\tfrac{1}{2}\dot{q}_3c_{q4}s_{q5}+\tfrac{1}{2}\dot{q}_1c_{q3}s_{q4}s_{q5}\right)p_{37} \qquad \text{(B.107)}$$

$$C_{65} = \left(\dot{q}_4c_{q5}s_{q6}-\dot{q}_1\left(\tfrac{3}{2}c_{q5}s_{q3}s_{q6}+c_{q3}c_{q4}s_{q5}s_{q6}\right)+\dot{q}_3s_{q4}s_{q5}s_{q6}\right)p_{11}+\left(\dot{q}_1\left(\tfrac{1}{2}s_{q3}s_{q5}-\right.\right.$$
$$\left.{c_{q6}}^2s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}c_{q4}c_{q5}+c_{q3}c_{q4}c_{q5}{c_{q6}}^2+c_{q3}c_{q4}c_{q5}c_{q6}s_{q5}s_{q6}\right)-\dot{q}_5s_{2q_6}+$$
$$\dot{q}_3\left(\tfrac{1}{2}c_{q5}s_{q4}-c_{q5}{c_{q6}}^2s_{q4}\right)-\dot{q}_4\left(\tfrac{1}{2}s_{q5}-{c_{q6}}^2s_{q5}\right)\left.\right)p_{12}+$$
$$\left(-\dot{q}_5\left(2{c_{q6}}^2-1\right)+\dot{q}_3\left(-c_{q4}{c_{q6}}^2+c_{q5}s_{q4}s_{q6}c_{q6}+\tfrac{1}{2}c_{q4}\right)+\right.$$
$$\left.\dot{q}_1\left(c_{q3}s_{q4}-2c_{q3}{c_{q6}}^2s_{q4}+c_{q6}s_{q3}s_{q5}s_{q6}-2c_{q3}c_{q4}c_{q5}c_{q6}s_{q6}\right)-c_{q6}\dot{q}_4s_{q5}s_{q6}\right)p_{14}+ \qquad \text{(B.108)}$$
$$\left(\dot{q}_4\left(c_{q6}{c_{q3}}^2-2c_{q6}{c_{q3}}^2{c_{q5}}^2-c_{q6}c_{q5}\right)+\dot{q}_1\left(c_{q5}c_{q6}s_{q3}+c_{q3}c_{q4}c_{q6}s_{q5}\right)-\right.$$
$$c_{q6}\dot{q}_3s_{q4}s_{q5}\left.\right)p_{15}-\dot{q}_2c_{q2}c_{q4}c_{q6}\;s_{q3}s_{q5}\,p_{16}+\dot{q}_2c_{q2}c_{q4}c_{q6}\;s_{q3}s_{q5}\,p_{17}-$$
$$\dot{q}_3c_{q4}c_{q6}s_{q5}\,p_{22}+\left(\dot{q}_1\left(\tfrac{1}{2}s_{q3}s_{q5}-\tfrac{1}{2}c_{q3}c_{q4}c_{q5}\right)+\tfrac{1}{2}\dot{q}_3c_{q5}s_{q4}\right)p_{37}$$

$$C_{66} = 0 \qquad \text{(B.109)}$$