

$$\begin{aligned}
& -\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) m_0 \left( \cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \right) \zeta_1'(t)^2 - \cos(\alpha(t)) \\
& \cos(\theta(t) + \psi(t)) M_{P1} \left( \cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \right) \zeta_{P1}'(t)^2 - \\
& \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) m_0 \left( \cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \right) \chi_1'(t)^2 - \\
& \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) M_{P1} \left( \cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \right) \\
& \chi_{P1}'(t)^2 + k_0 \eta_1(t) - k_0 (\eta_{P1}(t) - \eta_1(t)) - \\
& \frac{1}{2} m_0 \left( 2 (-\cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \alpha'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t))) \right. \\
& \left( \cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t) - \right. \\
& \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \eta_1'(t) \right) + \\
& 2 \cos(\alpha(t)) \alpha'(t) \left( \cos(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) + \sin(\alpha(t)) \eta_1'(t) \right) + \\
& 2 (\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \alpha'(t)) \\
& \left( \sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) + \cos(\theta(t)) R(t) \theta'(t) + \right. \\
& \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \eta_1'(t) \right) \Big) - \\
& \frac{1}{2} M_{P1} \left( 2 (-\cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \alpha'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t))) \right. \\
& \left( \cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) - \right. \\
& R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \\
& \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + \\
& 2 \cos(\alpha(t)) \alpha'(t) \left( \cos(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \sin(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + \\
& 2 (\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \alpha'(t)) \\
& \left( \sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \right. \\
& \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \\
& \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) \Big) + \frac{1}{2} m_0 \\
& \left( -2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \alpha'(t) \left( \cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) - \right. \right.
\end{aligned}$$

$$\begin{aligned}
& R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) + \\
& \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \eta_1'(t) \Big) - 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) \\
& \left( \cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t) - \right. \\
& \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \eta_1'(t) \right) + \\
& 2 \cos(\alpha(t)) \alpha'(t) \left( \cos(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) + \sin(\alpha(t)) \eta_1'(t) \right) - \\
& 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \alpha'(t) \left( \sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) + \right. \\
& \left. \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) + \right. \\
& \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \eta_1'(t) \right) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) \\
& \left( \sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t) + \cos(\theta(t)) R(t) \theta'(t) + \right. \\
& \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \eta_1'(t) \right) + \\
& 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( -\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t)^2 + 2 \sin(\alpha(t)) \right. \\
& \left. \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) \alpha'(t) - 2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \eta_1'(t) \right. \\
& \left. \alpha'(t) - \cos(\theta(t)) R(t) \theta'(t)^2 - \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t))^2 - \right. \\
& \left. 2 \sin(\theta(t)) R'(t) \theta'(t) - 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) \eta_1'(t) + \right. \\
& \left. \cos(\theta(t)) R''(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha''(t) - R(t) \sin(\theta(t)) \theta''(t) - \right. \\
& \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta''(t) + \psi''(t)) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \eta_1''(t) \right) + \\
& 2 \sin(\alpha(t)) \left( -\sin(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t)^2 + 2 \cos(\alpha(t)) \eta_1'(t) \alpha'(t) + \right.
\end{aligned}$$

$$\begin{aligned}
& \cos(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha''(t) + \sin(\alpha(t)) \eta_1''(t) \Bigg) + \\
& 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( -\cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha'(t)^2 - 2 \cos(\theta(t) + \psi(t)) \right. \\
& \quad \sin(\alpha(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t)) \alpha'(t) - 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \eta_1'(t) \alpha'(t) - \\
& \quad R(t) \sin(\theta(t)) \theta'(t)^2 - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta'(t) + \psi'(t))^2 + \\
& \quad 2 \cos(\theta(t)) R'(t) \theta'(t) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) \eta_1'(t) + \sin(\theta(t)) R''(t) - \\
& \quad \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) \alpha''(t) + \cos(\theta(t)) R(t) \theta''(t) + \cos(\alpha(t)) \\
& \quad \left. \cos(\theta(t) + \psi(t)) \left( \frac{L_0}{2} + \eta_1(t) \right) (\theta''(t) + \psi''(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \eta_1''(t) \right) \Bigg) + \\
& \frac{1}{2} M_{P1} \Big( -2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \alpha'(t) (\cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \\
& \quad (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \\
& \quad (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t))) - \\
& \quad 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) (\cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \\
& \quad (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \\
& \quad (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t))) + \\
& \quad 2 \cos(\alpha(t)) \alpha'(t) (\cos(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \sin(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t))) - \\
& \quad 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \alpha'(t) \\
& \quad (\sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \\
& \quad \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \\
& \quad \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t))) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \\
& \quad (\theta'(t) + \psi'(t)) (\sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \\
& \quad \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \\
& \quad \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t))) + \\
& \quad 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \Big( -\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t)^2 + \\
& \quad 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) \alpha'(t) - \\
& \quad 2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \alpha'(t) - \cos(\theta(t)) R(t) \theta'(t)^2 - \\
& \quad \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t))^2 - 2 \sin(\theta(t)) R'(t) \theta'(t) - \\
& \quad 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) (\eta_1'(t) + \eta_{P1}'(t)) + \cos(\theta(t)) R''(t) - \\
& \quad \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha''(t) - R(t) \sin(\theta(t)) \theta''(t) -
\end{aligned}$$

$$\begin{aligned}
& \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta''(t) + \psi''(t)) + \\
& \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1''(t) + \eta_{P1}''(t)) \Big) + \\
& 2 \sin(\alpha(t)) \Big( -\sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t)^2 + 2 \cos(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \alpha'(t) + \\
& \cos(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha''(t) + \sin(\alpha(t)) (\eta_1''(t) + \eta_{P1}''(t)) \Big) + \\
& 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \Big( -\cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t)^2 - \\
& 2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) \alpha'(t) - \\
& 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t)^2 - \\
& \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t))^2 + 2 \cos(\theta(t)) R'(t) \theta'(t) + \\
& 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) (\eta_1'(t) + \eta_{P1}'(t)) + \sin(\theta(t)) R''(t) - \\
& \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha''(t) + \cos(\theta(t)) R(t) \theta''(t) + \\
& \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta''(t) + \psi''(t)) + \\
& \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1''(t) + \eta_{P1}''(t)) \Big) \Big) + \\
& \Big( \mu m_0 \Big( 2 \Big( \frac{L_0}{2} + \eta_1(t) \Big) \sin^2(\alpha(t)) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \\
& \Big( \cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \Big( \frac{L_0}{2} + \eta_1(t) \Big) \Big) \Big) + \\
& 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \Big( R(t) \sin(\theta(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \Big( \frac{L_0}{2} + \eta_1(t) \Big) \Big) \Big) \Big) / \\
& \Big( 2 \Big( \sin^2(\alpha(t)) \Big( \frac{L_0}{2} + \eta_1(t) \Big)^2 + \Big( \cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \Big( \frac{L_0}{2} + \eta_1(t) \Big) \Big)^2 + \\
& \Big( R(t) \sin(\theta(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \Big( \frac{L_0}{2} + \eta_1(t) \Big) \Big)^2 \Big)^{3/2} \Big) + \\
& \Big( \mu M_{P1} \Big( 2 (L_0 + \eta_1(t) + \eta_{P1}(t)) \sin^2(\alpha(t)) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \\
& (\cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t))) + \\
& 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (R(t) \sin(\theta(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t))) \Big) \Big) / \\
& \Big( 2 \Big( \sin^2(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t))^2 + (\cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \\
& (L_0 + \eta_1(t) + \eta_{P1}(t)))^2 + (R(t) \sin(\theta(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \\
& (L_0 + \eta_1(t) + \eta_{P1}(t)))^2 \Big)^{3/2} \Big) = c_0 (\eta_{P1}'(t) - \eta_1'(t)) - c_0 \eta_1'(t)
\end{aligned}$$