\[
(Mg - k_a \cos \theta) \cos \phi = -k_a \cos \phi \cos (\theta_A - \phi) \\
(Mg - k_a \cos \theta) \sin \theta = k_a \cos \theta \sin (\theta_B - \phi) \\
Mg \cos \phi = 2k_a \sin (\theta_A - \phi) \cos (\theta_B - \phi) - k_a \cos (\theta_B - \phi)
\]

Work on this can go solve for \( \theta \). One finds

\[
Mg \cos \theta = k_a \cos \theta \cos (\theta_B - \phi) \sin (\theta_A - \phi) \\
0 = [k_a \cos \theta - k_a \cos \theta \cos (\theta_B - \phi) - \phi] \\
Mg + Mg \cos \theta = k_a \cos \theta \sin (\theta_A - \phi) - r_0 \\
0 = [\phi - \frac{\pi}{2} + k_a \cos \theta \sin (\theta_A - \phi) - \phi] \\
\frac{d\phi}{dt} = -\frac{Mg \cos \theta}{k_a} \\
\frac{d\theta}{dt} = \frac{1}{k_a} \\
\]

Assume \( \theta = \theta_0 \) is an equilibrium solution. Then one must have

The equation of motion becomes

So the equation of motion becomes

\[ \frac{d^2 \phi}{dt^2} = -\frac{Mg \cos \theta}{k_a} \]

\[ \frac{d\theta}{dt} = \frac{1}{k_a} \]

\[ \frac{d\phi}{dt} = \frac{1}{k_a} \]