We have the following dynamical system:

Note that we have no used for angular momentum as the Flywheel inverted pendulum model used to do. The key observation is that as shows [] is a non-holonomic constraint, i.e, cannot be integrate in the form of for a multibody system as proves []. The direct consequence is that there *no exists* an virtual angle and we can consider equation () as the full system. The consequence is that the Flywheel inverted pendulum is *overmodeled,* considering and controlling a variable that does not exists.Note that for a rigid body there exists an angle corresponding to the orientation of the body in the space (roll, pitch, yaw). There is no generalization of these variables for a multibody system.

So let’s compute the steady state of this system:

We have:

Note that we have no restrictions on the final angular momentum . This is because the angular momentum does not have a direct impact on the dynamics, although its analysis is necessary for Capturability. Actually we can just control through,fix and and the robot will never fall as long as the joint torques can set . But there is an issue with keeping : Nonzero angular momentum implies that some joints are still in movement. This issue is not contemplated in the reduced model, but the full model actually has bounds on the maximum angle joints . That’s why we should impose the additional final restriction:

We have the following dynamical system with contact surfaces:

Let’s define;

Problem: Given , find holding:

We have now: