

# Cubli: Dynamic Control of a Reaction Wheel Inverted Pendulum

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# Agenda

Cubli: Dynamic Control  
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System Description

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Classical Controller  
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# System Description

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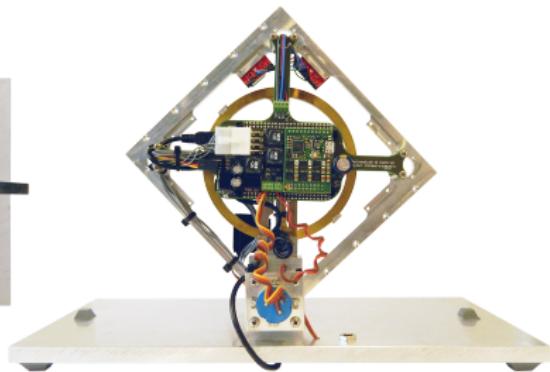
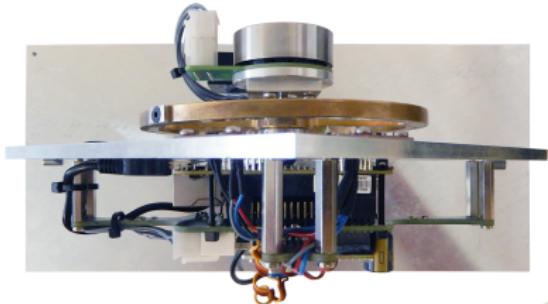
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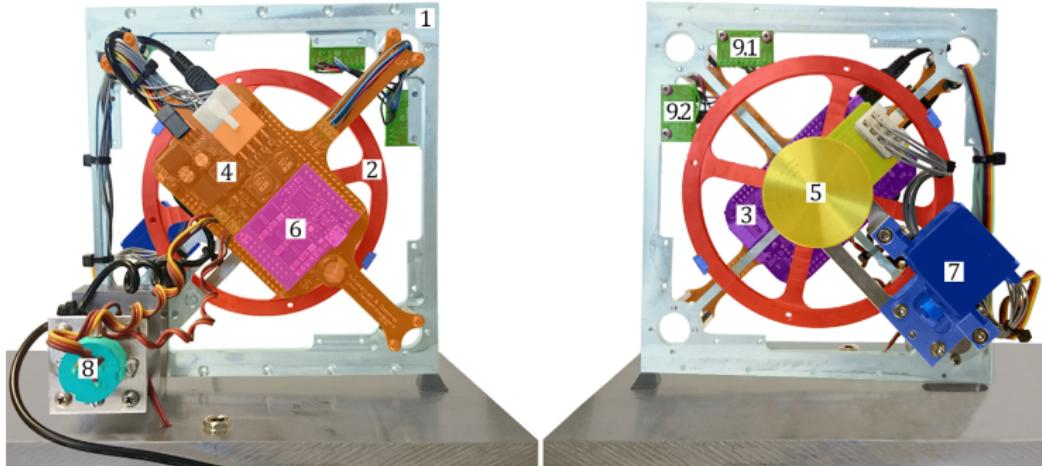
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# Requirements

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- ▶ Keep balancing from unstable equilibrium position
  - ▶ Starting out from equilibrium position at null velocity
- ▶ The prototype should be able to balance around 0 rad
  - ▶ Changing angle of baseplate within reasonable range

# Model Overview

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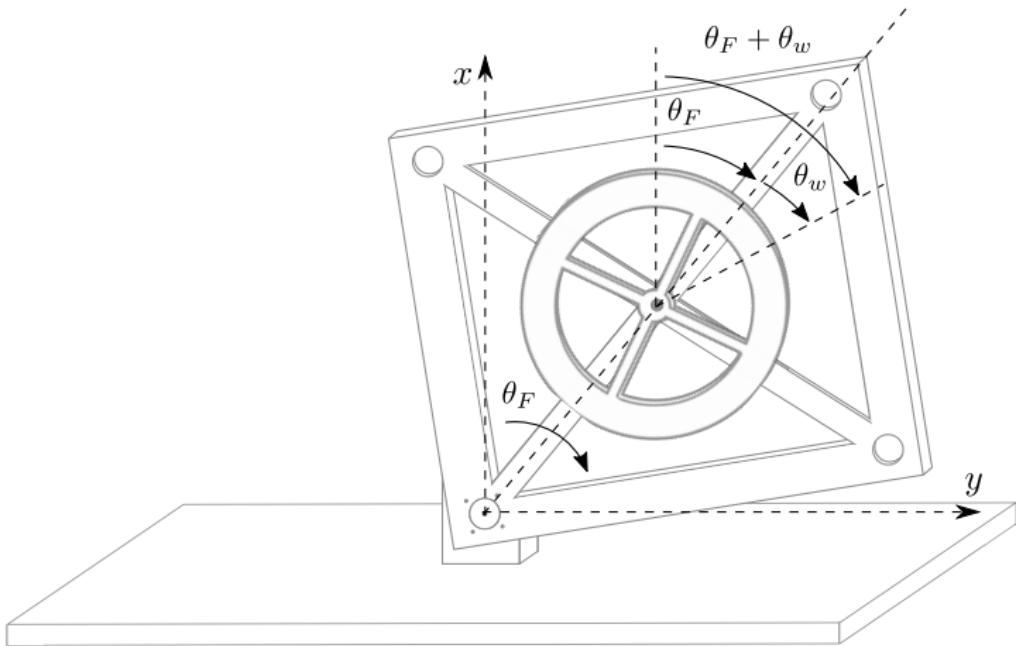
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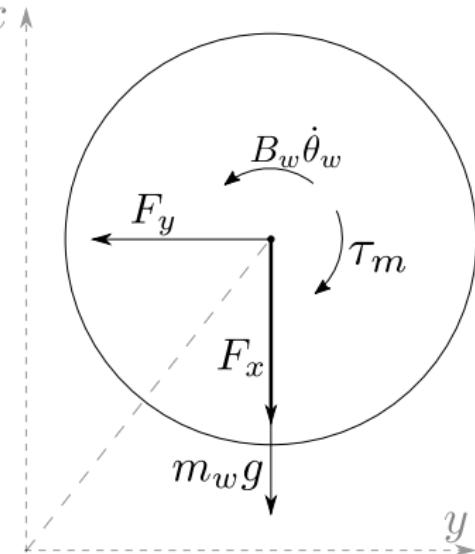
# Model

freebody diagram of the wheel

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$$J_w(\ddot{\theta}_F + \ddot{\theta}_w) = \tau_m - B_w \dot{\theta}_w$$

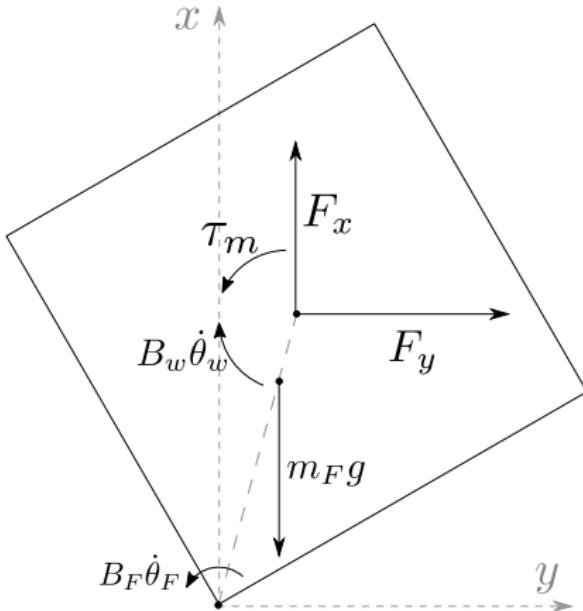
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freebody diagram of the frame

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$$J_F \ddot{\theta}_F = -B_F \dot{\theta}_F + I_F \times (m_F \cdot g) + I_w \times F - \tau_m + B_w \dot{\theta}_w$$



# Model Construction

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# Model

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## Linearization

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$$(J_F + m_w \cdot l_w^2) \Delta \ddot{\theta}_F = \\ -B_F \Delta \dot{\theta}_F + (m_F \cdot l_F + m_w \cdot l_w) \cdot g \cdot \Delta \theta_F - \Delta \tau_m + B_w \Delta \dot{\theta}_w$$

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# Model

## Blockdiagram

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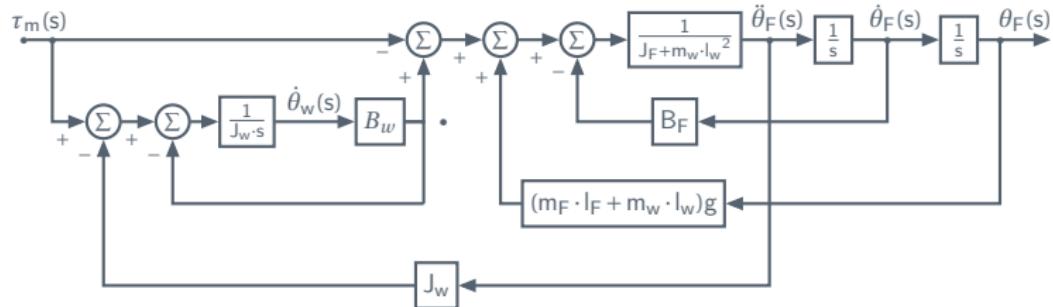
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# Stability Analysis

## Root Locus

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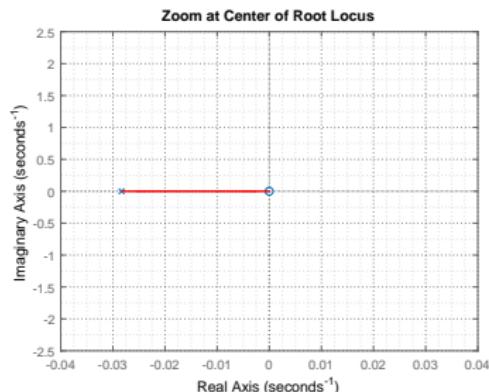
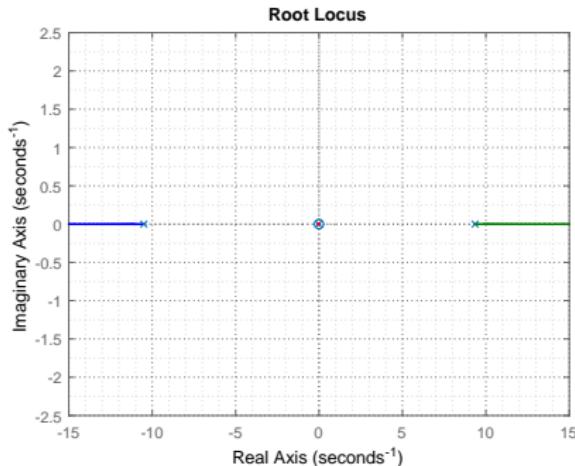
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Nyquist Plot

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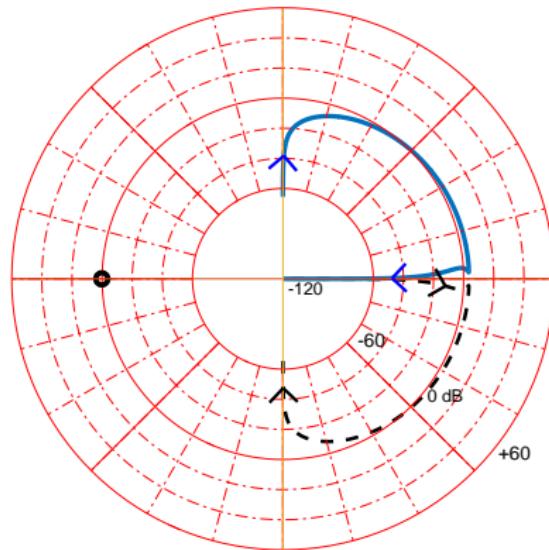
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## Nyquist Plot

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# Classical Controller Design

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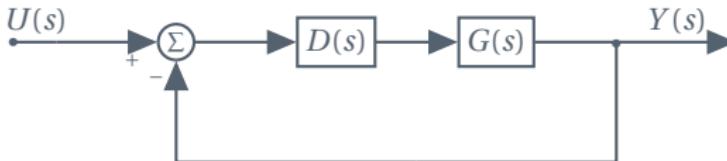
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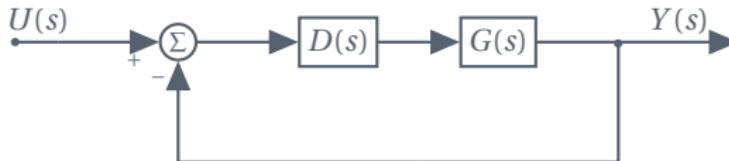
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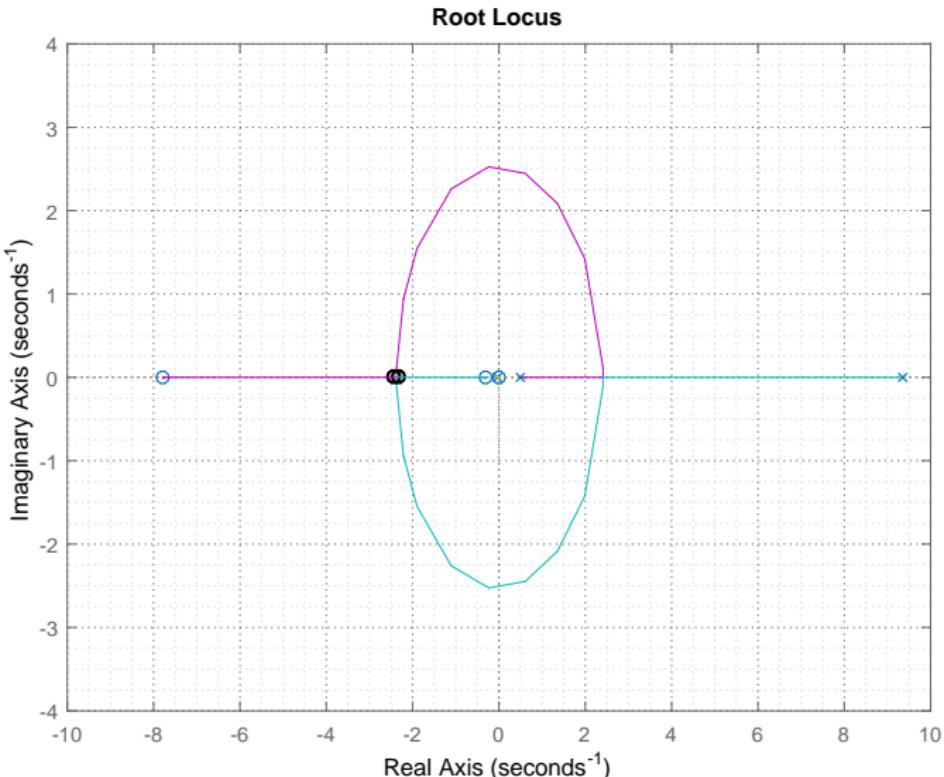
# Root Locus Designed Controller

## Final Root Locus

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# Root Locus Designed Controller

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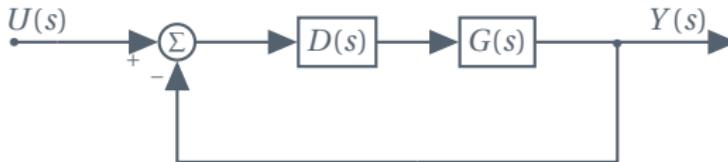
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