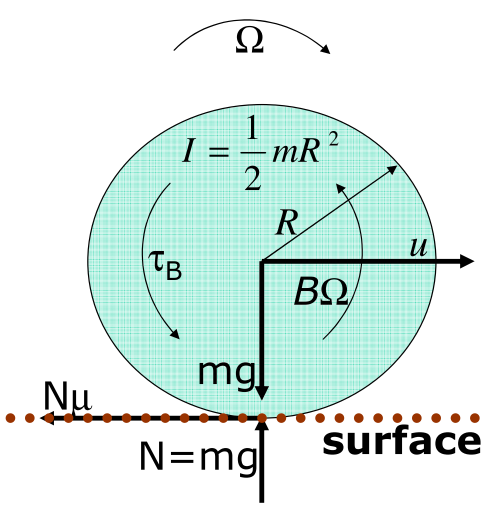
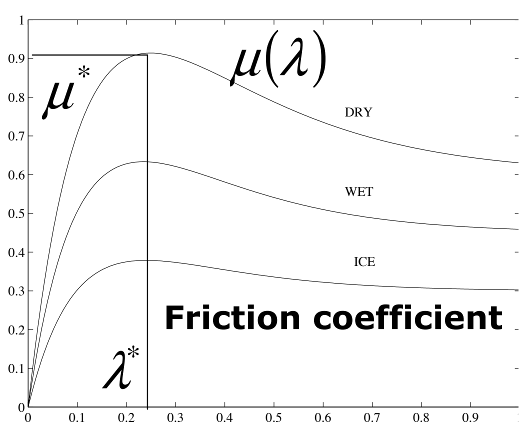
Antiskid Braking

Quarter Car Model





Slip:

$$\lambda(u,\Omega) = \frac{u - R\Omega}{u}$$

$$R\Omega \le u$$

Governing equations:

$$m\dot{u} = -N\mu(\lambda)$$

$$I\dot{\Omega} = -B\Omega + NR\,\mu(\lambda) - \tau_B$$

Control Law and Closed Loop System

Objective: The regulation of slip to set point λ_0

Measurements: $u, \dot{u}, \Omega$ (e.g., speedometer, accelerometer,tachometer)

Regulation error $\tilde{\lambda} \equiv \lambda - \lambda_0$ **and its dynamics:**

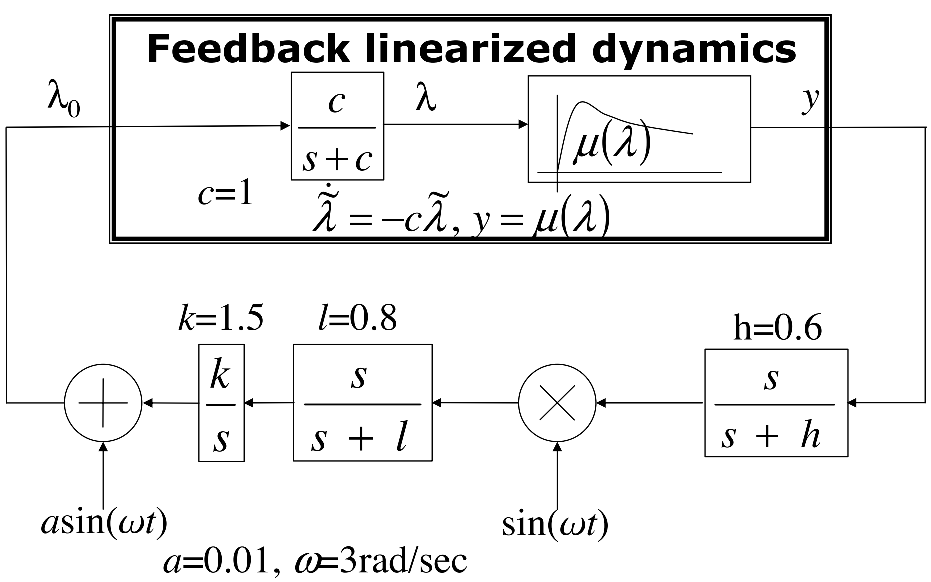
$$\dot{\tilde{\lambda}} = \dot{\lambda} = \left(\frac{R\,\Omega}{u^2} + \frac{mR^2}{Iu} \right) \dot{u} + \frac{RB}{Iu}\Omega + \frac{R}{Iu}\tau_B$$

Actuation: Braking torque τ_B

Control law (*feedback linearization*):

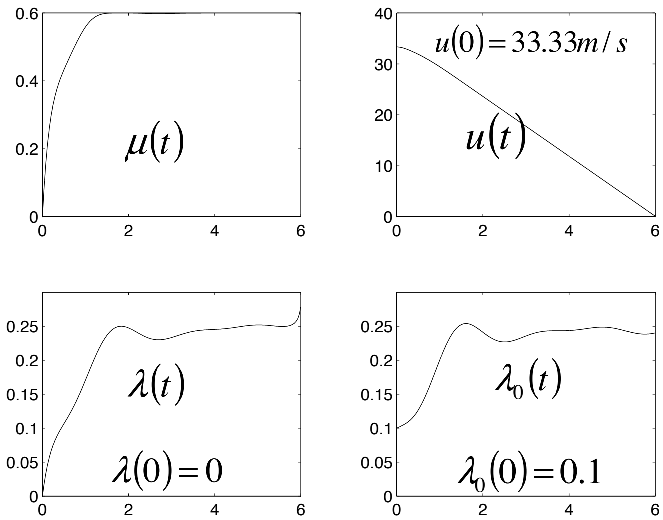
$$\tau_B = -\frac{cIu}{R}(\lambda - \lambda_0) - B\Omega - \frac{I\Omega}{u}\dot{u} - mR\,\dot{u},\ c > 0$$

Extremum Seeking to Find Optimum λ_0



Unicycle parameters: $m = 400\,\text{kg},\ B = 0.01,\ R = 0.3\text{m}$

Results



Simulation model:

$$\mu(\lambda) = 2\mu^* \frac{\lambda^* \lambda}{\lambda^{*2} + \lambda^2}, \lambda^* = 0.25, \mu^* = 0.6$$