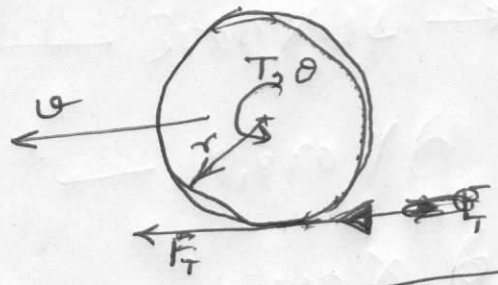
Single wheel rolling with slip



T - Torque by Motor
F_T - Traction Force.

(1)

$F_T = \mu(\lambda) N$ — N - normal Reaction (weight of wheel).

— λ slip

— μ - friction coef.

$$\lambda = \frac{(\dot{\theta} - \omega)}{y}$$

$$y = \begin{cases} \omega : \omega > \dot{\theta} \\ \dot{\theta} : \omega < \dot{\theta} \end{cases}$$

$\omega = \frac{v}{r}$ — v → linear velocity of wheel Center

$\dot{\theta}$ - angular velocity of wheel.

(2)
$$\mu = \begin{cases} \frac{(\lambda - 0.15)}{0.15} \frac{\mu_{apeak}}{} + \mu_{apeak}, & -0.15 < \lambda < 0.15 \\ -(\lambda - 0.15) \frac{0.34\ \mu_{apeak}}{0.85} + \mu_{apeak}, & 0.15 \leq \lambda \leq 1.0 \\ -(\lambda + 0.15) \frac{0.34\ \mu_{apeak}}{0.85} - \mu_{apeak}, & -0.15 \geq \lambda \geq -1.0 \end{cases}$$

$\mu_{apeak} = 0.10, 0.30, 0.80$.

$\Rightarrow$ $F = M_w \ddot{x}$ $\quad m_w$ - mass of wheel

$\oplus \tau = J_w \ddot{\theta} + F_0 r$ $\quad r$ - Radius of the wheel.

J - Moment of Inertia of wheel about ~~the~~ its CM

Let

$x_1 = x$

$x_3 = \theta$

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{pmatrix} = \begin{bmatrix} x_2 \\ F/M_w \\ x_4 \\ -r F/J_w \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1/J_w \end{bmatrix} T$$

$F = \mu(\lambda)$, $\omega = \frac{v}{r} = \frac{x_2}{r}$

$\lambda = \dfrac{\left(x_4 - \frac{x_2}{r}\right)}{y}$ $\quad$ where $y = x_2/r$; $\frac{x_2}{r} > x_4$

or x_4 ; $\frac{x_2}{r} < x_4$

using (2)

we get $F = f(x_4, x_2)$

ODE Solver

$[t, y] = ode15s(@slipmodel, [0\ 20], [0; 0]);$

function dy = slipmodel(t, y).

$dy(1) = y(2)$

$dy(2) = F_T(y(4), y(2))/Mw$

$dy(3) = y(4)$

$dy(4) = -r\,F_T(y(4), y(2))/Jw + \frac{Torq(t)}{Jw}$

function F = $F_T(y_4, y_2)$

if $\frac{y_2}{r} > y_4$

$\lambda = \frac{y_4 - y_2/r}{y_2/r} = \frac{y_4 r}{y_2} - 1$

else

$\lambda = \frac{y_4 - y_2/r}{y_4} = 1 - \frac{y_2}{y_4 r}$

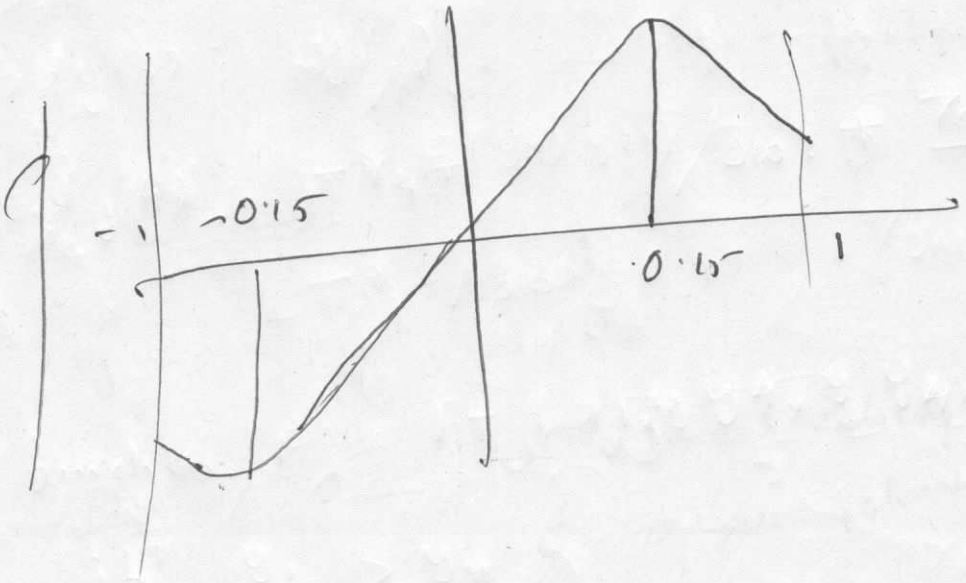
if $(-0.15 < \lambda)$ & $(\lambda < 0.15)$

$\mu =$

if $(0.15 \leq \lambda) \& (\lambda \leq 1.0)$

if $(-0.15 \geq \lambda) \& (\lambda \geq -0.1)$.

$F = \mu M_W g$; N = weight of wheel.



function T = Torq(t).

if $(t \geq 0) \& (t \leq 2.5)$

$T = \frac{4}{2.5} \times t$.

else

if $(t > 2.5) \& (t < 7.5)$

$T = 4$

else

if $(t \geq 7.5) \& (t < 10)$

else $T = 4 - \frac{4}{2.5}(t - 7.5)$