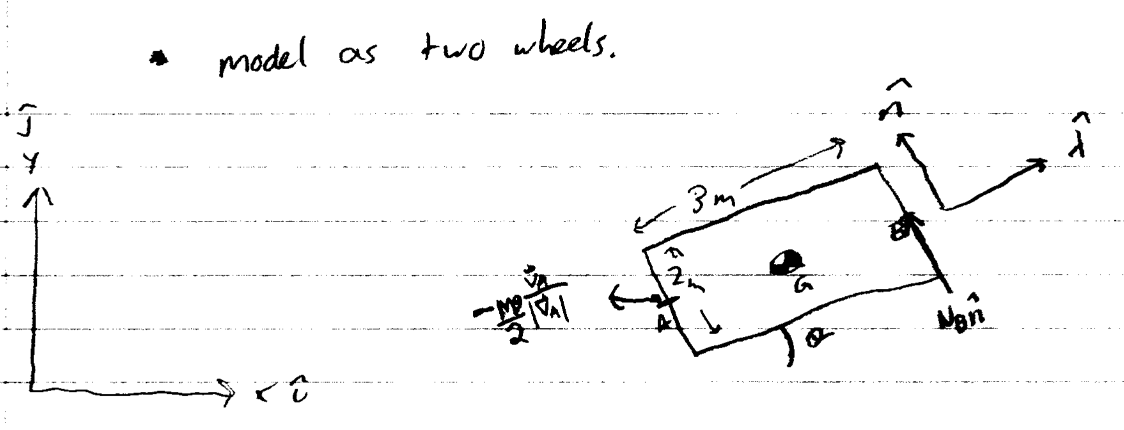
- model as two wheels.



$\vec{V}_A = \vec{V}_B + \vec{V}_{A/B} = V_B\hat{\lambda} + \dot{\theta}k \times \vec{r}_{A/B}$
$= V_B\hat{\lambda} + ((\dot{\theta}k) \times (-3\hat{\lambda})) = V_B\hat{\lambda} - 3\dot{\theta}\hat{n}$

$\vec{V}_G = \vec{V}_B + \vec{V}_{G/B} = V_B\hat{\lambda} + (\dot{\theta}k \times \vec{r}_{G/B}) = V_B\hat{\lambda} + ((\dot{\theta}k) \times (-1.5\hat{\lambda}))$
$= V_B\hat{\lambda} - 1.5\dot{\theta}\hat{n}$

$|V_A| = \sqrt{V_B^2 + 9\dot{\theta}^2}$

Force due to friction $= -\frac{mg}{2}\left(\frac{V_B\hat{\lambda} - 3\dot{\theta}\hat{n}}{\sqrt{V_B^2 + 9\dot{\theta}^2}}\right)$

$\vec{a}_G = \frac{d}{dt}(\vec{V}_G) = \dot{\vec{V}}_B\hat{\lambda} + \vec{V}_B\dot{\hat{\lambda}} + (-1.5\ddot{\theta}\hat{n} + (-1.5\dot{\theta}\dot{\hat{n}}))$
$= \dot{\vec{V}}_B\hat{\lambda} + \vec{V}_B\dot{\hat{\lambda}} - 1.5\ddot{\theta}\hat{n} - 1.5\dot{\theta}\dot{\hat{n}}$

$\dot{\hat{\lambda}} = \dot{\theta}\hat{n}$
$\dot{\hat{n}} = -\dot{\theta}\hat{\lambda}$

$\vec{a}_G = \dot{\vec{V}}_B\hat{\lambda} + \vec{V}_B\dot{\theta}\hat{n} - 1.5\ddot{\theta}\hat{n} + 1.5\dot{\theta}^2\hat{\lambda}$
$= (\dot{\vec{V}}_B + 1.5\dot{\theta}^2)\hat{\lambda} + (\vec{V}_B\dot{\theta} - 1.5\ddot{\theta})\hat{n}$

Try to find $\dot{\vec{V}}_B$:
LMB: $-\frac{mg}{2}\left(\frac{V_B\hat{\lambda} - 3\dot{\theta}\hat{n}}{\sqrt{V_B^2 + 9\dot{\theta}^2}}\right) + N_B\hat{n} = m\vec{a}_G$

$\{\}\cdot\hat{\lambda} \Rightarrow \frac{-mgV_B}{2\sqrt{V_B^2 + 9\dot{\theta}^2}} = m(\dot{V}_B + 1.5\dot{\theta}^2)$

$\dot{V}_B = \frac{5V_B}{\sqrt{V_B^2 + 9\dot{\theta}^2}} - 1.5\dot{\theta}^2$

$I_{zz}^G = \frac{1}{12}m(2^2 + 3^2) = \frac{13}{12}m$

AMB/B: $\vec{r}_{A/B} \times \left(-\frac{mg}{2}\left(\frac{V_B\hat{\lambda} - 3\dot{\theta}\hat{n}}{\sqrt{V_B^2 + 9\dot{\theta}^2}}\right)\right) = \vec{r}_{G/B} \times \vec{a}_G m + I_{zz}^G\ddot{\theta}\hat{k}$

$\vec{a}_G$: $(\dot{\vec{V}}_B + 1.5\dot{\theta}^2)\hat{\lambda} + (\vec{V}_B\dot{\theta} - 1.5\ddot{\theta})\hat{n}$

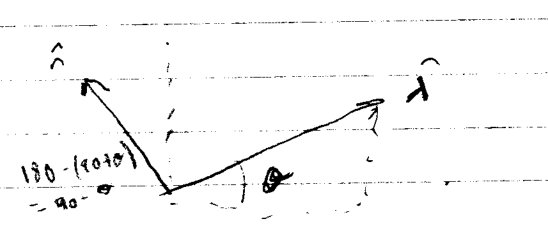
$\vec{r}_{A/B} = -3\hat{\lambda}$
$\vec{r}_{G/B} = -1.5\hat{\lambda}$

$\Rightarrow \frac{-\frac{mg}{2}9\dot{\theta}}{\sqrt{V_B^2 + 9\dot{\theta}^2}}\hat{k} = -1.5m(\vec{V}_B\dot{\theta} - 1.5\ddot{\theta})\hat{k} + \frac{13}{12}m\ddot{\theta}\hat{k}$

$\{\}\cdot\hat{k}$

$\Rightarrow \frac{-g9\dot{\theta}}{2\sqrt{V_B^2 + 9\dot{\theta}^2}} = -1.5\vec{V}_B\dot{\theta} + 2.25\ddot{\theta} + \frac{13}{12}\ddot{\theta}$
$= -1.5\vec{V}_B\dot{\theta} + \frac{10}{3}\ddot{\theta}$

$\ddot{\theta} = \frac{-27g\dot{\theta}}{20\sqrt{V_B^2 + 9\dot{\theta}^2}} + \frac{9}{20}\vec{V}_B\dot{\theta}$



$\cos\theta = \frac{x}{1}$ $x = \cos\theta\hat{i}$ $\hat{\lambda} = \cos\theta\hat{i} + \sin\theta\hat{j}$
$y = \sin\theta\hat{j}$

$\cos(90 - \theta) = \frac{x}{1}$ $x = -\sin\theta\hat{i}$

$\sin(90 - \theta) = \frac{y}{1}$ $y = +\cos\theta\hat{j}$ $\hat{n} = -\sin\theta\hat{i} + \cos\theta\hat{j}$

$\dot{\theta} = w$ • $\dot{x} = v$

$\dot{w} = \frac{-27gw}{20\sqrt{V_B^2 + 9w^2}} + \frac{9}{20}\dot{V}_B w$

$\dot{V}_B = \frac{5V_B}{\sqrt{V_B^2 + 9w^2}} - 1.5w^2$

$\dot{V}_G = (\dot{V}_B + 1.5w^2)(\cos\theta\hat{i} + \sin\theta\hat{j}) + (V_B w - 1.5\dot{w})(-\sin\theta\hat{i} + \cos\theta\hat{j})$

$\dot{V}_{Gx} = \cos\theta(\dot{V}_B + 1.5w^2) - \sin\theta(V_B w - 1.5\dot{w})$

$\dot{V}_{Gy} = \sin\theta(\dot{V}_B + 1.5w^2) + \cos\theta(V_B w - 1.5\dot{w})$

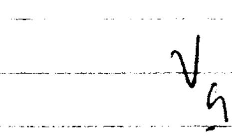
$V_G = V_B - 1.5\dot{\theta}\hat{n}$

Matlab

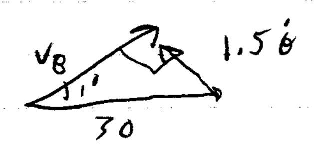
$z_0: [\theta_0, w_0, \cancel{X_{B0}}, V_{B0}, X_{G0}, Y_{G0}, \cancel{V_{xG0}}, \cancel{V_{yG0}}]$

X_{B0}: $\cos(.017) = \frac{x}{1.5}$ $x = 1.499$ $y = 4.569$
duh $= 1.5$

V_{B0}: $V_B = V_G + V_{B/G}$



$V_B = V_G + V_{B/G}$



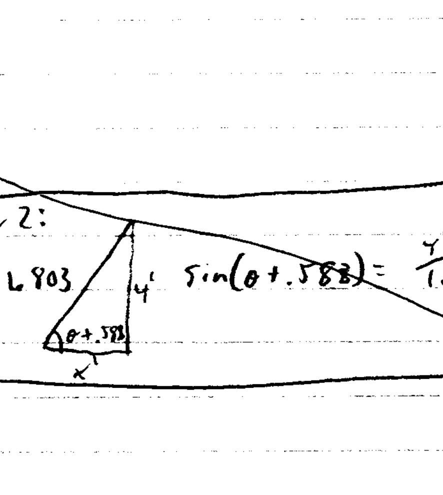
$\sin(1°) = \frac{1.5\dot{\theta}}{30}$ $w_0 = .349$

$\cos(1°) = \frac{V_B}{30}$ $V_{B0} = 29.9954$

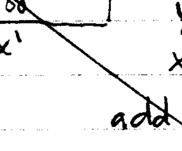
$\vec{V}_G = V_B\hat{\lambda} - 1.5\dot{\theta}\hat{n}$
$= V_B(\cos\theta\hat{i} + \sin\theta\hat{j}) - 1.5\dot{\theta}(-\sin\theta\hat{i} + \cos\theta\hat{j})$

$\vec{V}_{Gx} = V_B\cos\theta + 1.5\dot{\theta}\sin\theta$
$\vec{V}_{Gy} = V_B\sin\theta - 1.5w\cos\theta$
} use these for Matlab instead of accelerations

More Matlab crap:
drawing: given x_G, y_G, θ



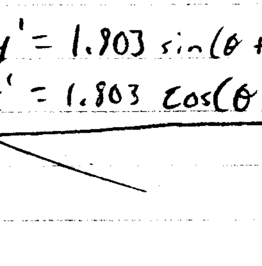
find ϕ



$\tan\phi = \frac{1}{1.5}$
$\phi = 33.69°$
$= .588$ radians

$\beta = \theta - \phi = \theta - .588$

corner 1



$h = \sqrt{1^2 + 1.5^2}$
$= 1.803$

$\sin(\theta - .588) = \frac{y'}{1.803}$
$y' = 1.803\sin(\theta - .588)$
$x' = 1.803\cos(\theta - .588)$
add these to x and y to get corner 1

corner 2:

$\sin(\theta + .588) = \frac{y'}{1.803}$ $y' = 1.803\sin(\theta + .588)$
$x' = 1.803\cos(\theta + .588)$

30