Tir lat. sl.p


$$
V_{c}^{2}=u^{2}+\dot{x}^{2}+\dot{a}^{2} \dot{\theta}^{2}+2 u a \dot{\theta} \sin \theta+2 \dot{x} a \dot{\theta} \cos \theta
$$

once yon have non-linm $v_{c}^{2}$ you cam charge $\sin \theta \rightarrow \theta$

$$
\cos \theta \rightarrow 1
$$

but not!

$$
\begin{aligned}
& \dot{\dot{y}}^{2} \rightarrow 0 \\
& \dot{x} \dot{\theta} \rightarrow 0 \text { edc }
\end{aligned}
$$

$$
\begin{aligned}
& M I_{c} s^{4}+\left(I_{c}+m b^{2}\right)\left(c_{\alpha} / u\right) s^{3}+\left[\left(I_{c}+m a^{2}\right) k+m b c_{\alpha}\right] s^{2}
\end{aligned}
$$

$$
\begin{aligned}
& \left(I_{c}+m a^{2}\right) k+m b c_{2}<0 \Rightarrow \text { unstabh } \Rightarrow b<\frac{-\left(I_{c}+m a^{2}\right) k}{m c_{\alpha}}
\end{aligned}
$$

$$
c_{\alpha}(a+b) k<0 \quad \Rightarrow \text { unstabl } \quad \Rightarrow \quad b<-a
$$


that $\alpha=0$, wop the lems not associated $C_{\alpha} \quad\left(C_{\infty} \rightarrow \infty\right)$

$$
a_{1} a_{2}>a_{0} a_{3} \Rightarrow \text { stability }
$$

$$
\frac{m b(a+b)^{2} k}{h}>\frac{\left(I_{c}+m_{b}\right)(a+h) k}{h} \Rightarrow m a b>I_{c} \text { for stability }
$$

increasing $I_{c}$ lager than mab $\Rightarrow$ unstable! if $b$ is very small can get instability!


$$
b>\frac{I_{c}}{m a} \rightarrow \text { fur stability }
$$

What about speed dependina? rototimil dares at the hitch


$$
\bar{I}_{0}=-F(a+b)-c \dot{\theta}
$$

using $\because$ can get

$$
\begin{aligned}
& \frac{\left(I_{c}+m b\right)}{h} s^{3}+\left(\frac{c}{U}+m b\right) s^{2}+(a+b)^{2} \frac{k}{u} s+(a+h) k=0 \\
& \frac{c(a+h)}{h}+m a b>I_{c} \Rightarrow \text { for stability } \\
& U<\frac{c(a+b)}{I_{c}-m a b}
\end{aligned}
$$

$\rightarrow$ crital speed may vehides haw,

$$
\begin{aligned}
& {\left[\left(I,+m b^{2}\right) / u\right] s^{3}+m b^{a_{2}}+\frac{\left.a_{1}+{ }^{2}\right)^{2} k}{u} s+(a+b) k=0 \quad \text { char. } a_{0} \text { - }} \\
& \begin{array}{c}
\text { nu } \\
\text { Slip! }
\end{array} \\
& m b<0 \Rightarrow b<0 \\
& \underbrace{u}_{i<a \rightarrow 1}
\end{aligned}
$$

cniticol speeds

