

G.6

Soln

(1)

The linear dynamics are

$$(m_c + 2m_r) \ddot{z} = -F_0 \theta - \mu \dot{z}$$

$$(m_c + 2m_r) \ddot{h} = \tilde{F}$$

$$(J_c + 2m_r d^2) \ddot{\theta} = \tilde{\tau}$$

Taking the Laplace transform + setting initial conditions to zero gives

$$(m_c + 2m_r) s^2 Z(s) = -F_0 \tilde{\theta}(s) - \mu s Z(s) \quad (1)$$

$$(m_c + 2m_r) s^2 H(s) = \tilde{F}(s) \quad (2)$$

$$(J_c + 2m_r d^2) s^2 \tilde{\theta}(s) = \tilde{\tau}(s) \quad (3)$$

Solving for $H(s)$ in (2) gives

$$H(s) = \frac{\left(\frac{1}{m_c + 2m_r} \right) \tilde{F}(s)}{s^2} \quad (4)$$

these are the ~~key~~ linearized longitudinal dynamics.

Solving for $\tilde{\theta}(s)$ in (3) gives

$$\tilde{\theta}(s) = \frac{\left(\frac{1}{J_c + 2m_r d^2} \right) \tilde{\tau}(s)}{s^2} \quad (5)$$

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Soln

(2)

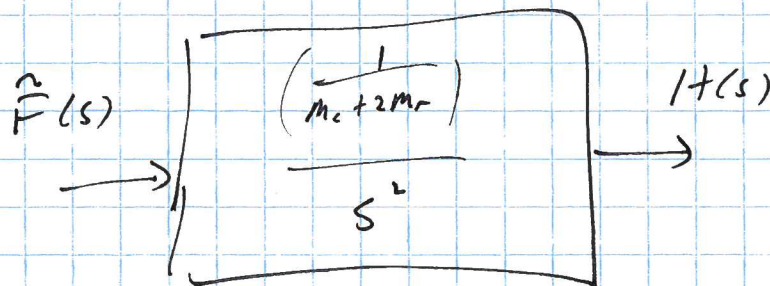
Solving for $Z(s)$ in (1) gives

$$\left[(m_c + 2m_r) s^2 + \mu s \right] Z(s) = -F_0 \Theta(s) \quad (6)$$

$$\Rightarrow Z(s) = \frac{-F_0}{(m_c + 2m_r) s^2 + \mu s} \Theta(s) \quad (7)$$

$$\Rightarrow \boxed{Z(s) = \frac{-\left(\frac{F_0}{m_c + 2m_r}\right)}{s^2 + \left(\frac{\mu}{m_c + 2m_r}\right)s} \Theta(s)} \quad (8)$$

The Block diagram for the longitudinal motion is therefore



and for the lateral motion it is

