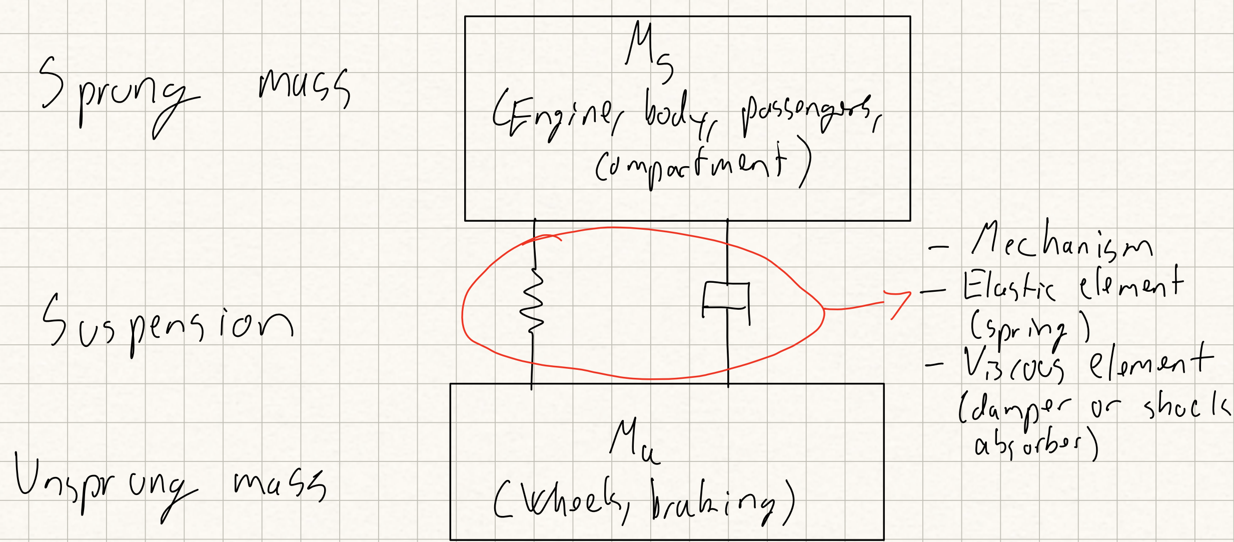
Fundamentals

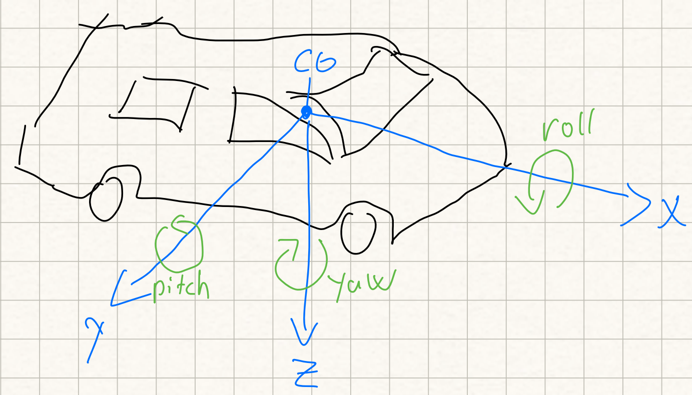
Scope

- Longitudinal dynamics
  - Acceleration
  - Braking
- Vertical dynamics
  - Ride ($f < 50$ Hz)
  - Noise ($50 \text{ Hz} < f < 20 \text{ kHz}$)
- Lateral dynamics
  - Handling
  - Manoeuvring

Lumped parameter modeling



Vechicle reference frame



- CG centre of gravity
- x-axis: longitudinal, forward
- y-axis: lateral, pointing left
- z-axis: vertical, aligned with g

Earth-fixed axis system

- X_0-axis: forward direction
- Y_0-axis: lateral direction
- Z_0-axis: Vertical direction, aligned with $-g$

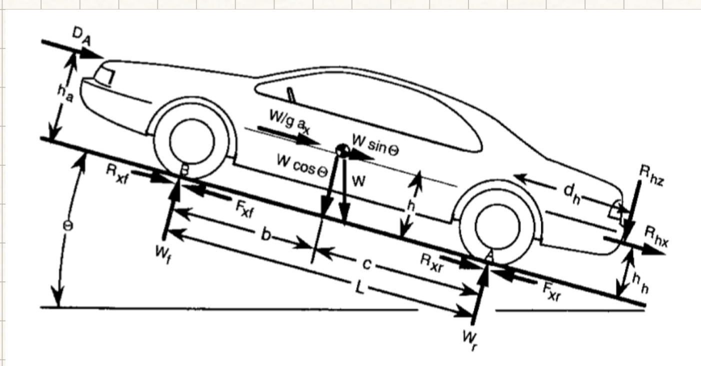
Rigid-body dynamics

$$\sum F_x = M \cdot a_x$$

(1-directional motion)

$$\sum T_x = I_{xx} \cdot \alpha_x$$

(Planar motion)



Find W_f and W_r

To find W_f, use point A.

For torque: counter-clockwise rotation positive

$$-W_f \cdot L - D_A h_A - \frac{W}{g} a_x h - W \sin(\theta) h + W \cos(\theta) c = 0$$

$$W_f = \frac{1}{L}\left[W \cos(\theta) c - W \sin(\theta) h - \frac{W}{g} a_x h - D_A h_A\right]$$

To find W_r, we use point B

$$W_r L - D_A h_A - \frac{W}{g} a_x h - W \cos(\theta) b - W \sin(\theta) h = 0$$

$$W_r = \frac{1}{L}\left[W \cos(\theta) b + W \sin(\theta) h + \frac{W}{g} a_x h + D_A h_A\right]$$

When static and level:

$V = 0$, $\theta = 0$, $V = 0 \Rightarrow a = 0$

$$W_{fs} = \frac{1}{L}\left[W \cos(0) c - W \sin(0) h - \frac{W}{g} 0 h - 0 h_A\right]$$

$$= \frac{1}{L} W c$$

$$W_{rs} = \frac{1}{L}\left[W \cos(0) b + W \sin(0) h + \frac{W}{g} 0 \cdot h + 0 h_A\right]$$

$$= \frac{1}{L} W b$$

$$W_{fs} + W_{rs} = \frac{1}{L} W c + \frac{1}{L} W b$$

$$= \frac{1}{L} W (c + b) \quad , \quad c + b = L$$

$$= W$$

Static on upward hill:

$a_x = 0, \quad \theta > 0$

$\cos(\theta) < 1, \quad \sin(\theta) > 0$

$W_f = \frac{1}{L}\left[W\cos(\theta)c - W\sin(\theta)h\right]$

$W_r = \frac{1}{L}\left[W\cos(\theta)b + W\sin(\theta)h\right]$

$W_f < W_{fs}$