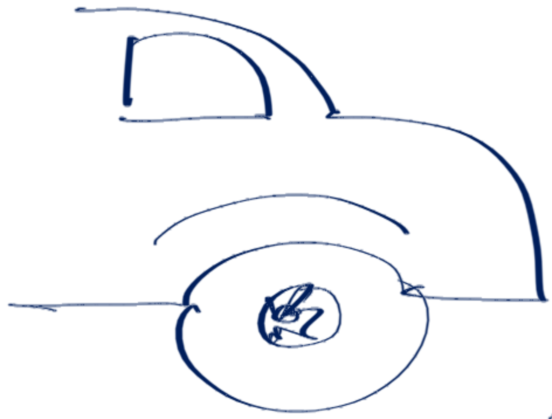
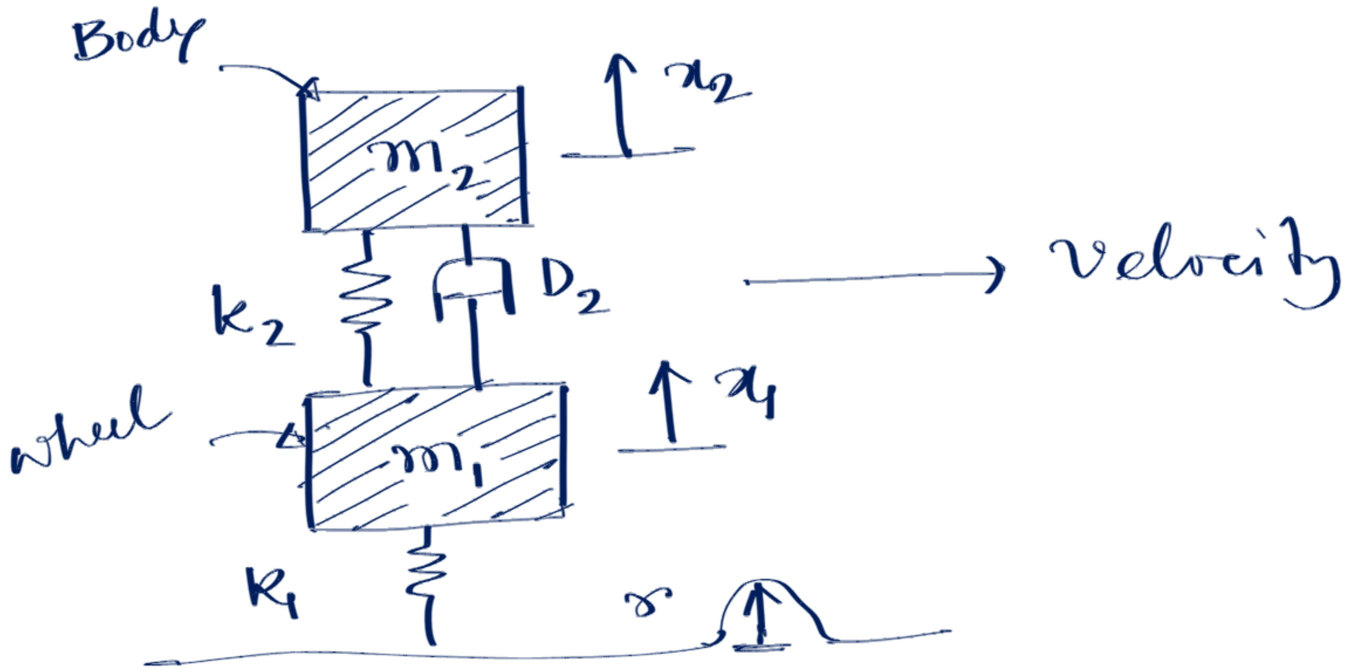
– Modelling :

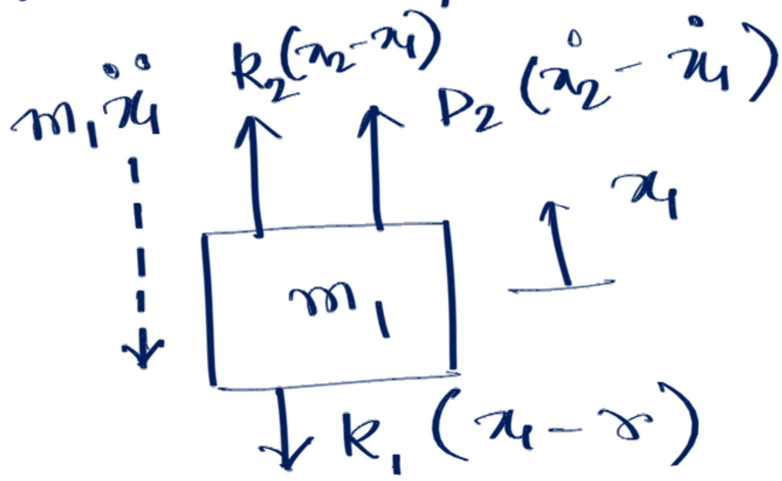


Quarter-car-suspension model



Job: Find the TF from r to x_2.

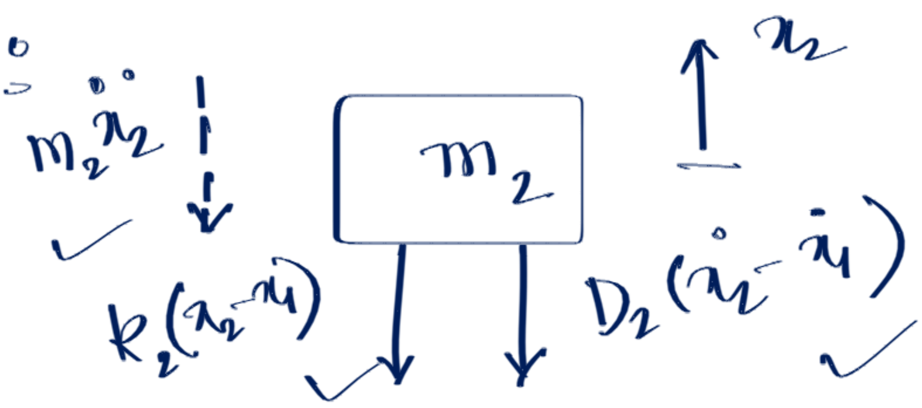
FBD 1:



$$M_1 s^2 X_1(s) + k_1 X_1(s) - k_1 R(s) =$$
$$k_2 X_2(s) - k_2 X_1(s) + D_2 s X_2(s) - D_2 s X_1(s)$$

$$\Rightarrow \boxed{\left[M_1 s^2 + D_2 s + (k_1 + k_2)\right] X_1(s) - (D_2 s + k_2) X_2(s) = k_1 R(s)} \quad (1)$$

FBD 2:



$$M_2 s^2 X_2(s) + K_2 X_2(s) - K_2 X_1(s) + D_2 s X_2(s) - D_2 s X_1(s) = 0$$

$$\Rightarrow \boxed{-(D_2 s + K_2) X_1(s) + (M_2 s^2 + D_2 s + K_2) X_2(s) = 0} \quad -(2)$$

Combining the two eqns together,

$$\begin{bmatrix} M_1 s^2 + (K_1+K_2) + D_2 s & -(K_2 + D_2 s) \\ -(K_2 + D_2 s) & M_2 s^2 + K_2 + D_2 s \end{bmatrix} \begin{bmatrix} X_1(s) \\ X_2(s) \end{bmatrix} = \begin{bmatrix} K_1 \\ 0 \end{bmatrix} R(s)$$

By Cramer's rule

$$X_2(s) = \frac{\begin{vmatrix} M_1 s^2 + D_2 s + (K_1 + K_2) & K_1 R(s) \\ -(K_2 + D_2 s) & 0 \end{vmatrix}}{\begin{vmatrix} M_1 s^2 + D_2 s + (K_1 + K_2) & -(K_2 + D_2 s) \\ -(K_2 + D_2(s)) & M_2 s^2 + D_2(s) + K_2 \end{vmatrix}}$$

$$= \frac{(D_2 s + K_2) K_1 \; R(s)}{\Delta(s)}$$

$$\Rightarrow \boxed{\frac{X_2(s)}{R(s)} = \frac{(D_2 s + K_2) K_1}{\Delta(s)}}$$