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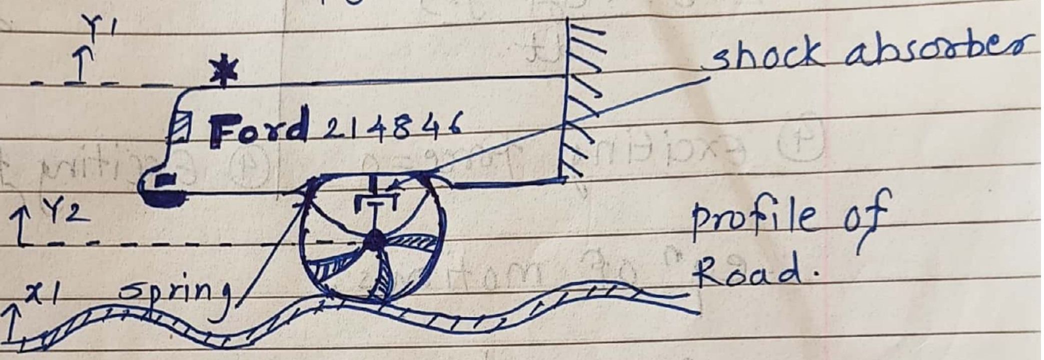
Q 2] The suspension system for one wheel of an old-fashioned pickup truck is illustrated. The mass of the vehicle is m1 and mass of wheel is m2. The suspension spring has spring constant k1 and the tire had spring constant k2. The damping constant of shock absorber is b. Obtain math. model which represent vehicle responce to bump in road. and simullate for 100 sec. Creat dummy input signal to represent bumpy road using Matlab.



Ans: from suspension shown in above problem,
mass of vehiche = m_1
mass of wheel = m_2
suspensens spring constant k_1
~~suspension~~ tire spring constant = k_2
damping shock absorber is b

$\therefore$ Transfer function $= \frac{Y_1(s)}{X_1(s)}$,

represens responce of vehicle to bumpy road.
by freebody diagram analysis,

Inertial force + Restoring force + Damping force = Exciting force.

∴ force acting on Mass m_1 :

① Inertial force
$= m_1 \frac{d^2 y_1}{dt^2}$

② Restoring force
$= k_1 (y_1 - y_2)$

③ Damping force
$= b . \frac{d(y_1 - y_2)}{dt}$

④ Exciting force $= 0$

∴ force acting on mass m_2 :

① Inertial force
$= m_2 \frac{d^2 y_2}{dt^2}$

② Restoring force
$= k_1 . (y_2 - y_1) + k_2 y_2$

③ Damping force
$= b \frac{d(y_2 - y_1)}{dt}$

④ Exciting force $= k_2 x$

∴ eqn of motions,

$$m_1 \frac{d^2 y_1}{dt^2} + b \frac{d(y_1 - y_2)}{dt} + k_1 (y_1 - y_2) = 0 \quad \because \text{for } m_1 \qquad \text{①}$$

$$m_2 \frac{d^2 y_2}{dt^2} + b \frac{d(y_2 - y_1)}{dt} + k_1 (y_2 - y_1) + k_2 y_2 = k_2 x$$

$\because$ for m_2 ②

appling Laplas transformation,

assuming zero initial condition

$$m_1 s^2 Y_1(s) + b s (Y_1(s) - Y_2(s)) + k_1 (Y_1(s) - Y_2(s)) = 0$$

$$m_2 s^2 Y_2(s) + b s (Y_2(s) - Y_1(s)) + k_1 (Y_2(s) - Y_1(s)) + k_2 Y_2(s) = k_2 X(s)$$

as we know,

$$L\left\{\frac{d z(t)}{dt}\right\} = s Z(s) \quad \& \quad L\left\{\frac{d^2 z(t)}{dt^2}\right\} = s^2 Z(s)$$

Rearrangin eqs,

$$(m_1 s^2 + bs + k_1) \cdot Y_1(s) - (bs + k_1) \cdot Y_2(s) = 0$$

$$(-(bs + k_1)) \cdot Y_1(s) + (m_2 s^2 + bs + k_1 + k_2) Y_2(s) = k_2 X(s)$$

To get, $\frac{Y_1(s)}{X(s)}$, $Y_2(s) = \frac{(m_1 s^2 + bs + k_1) \cdot Y_1(s)}{(bs + k_1)}$

$$-(bs + k_1) Y_1(s) + (m_2 s^2 + bs + k_1 + k_2) \frac{(m_1 s^2 + bs + k_1) \cdot Y_1(s)}{(bs + k_1}$$

$$= k_2 \cdot X(s)$$

$$\left[-(bs + k_1)^2 + (m_2 s^2 + bs + k_1 + k_2)(m_1 s^2 + bs + k_1) \right] \cdot Y_1(s) =$$

$$k_2 (bs + k_1) \cdot X(s)$$

$\therefore$

$$\frac{Y_1(s)}{X(s)} = \frac{k_2 (bs + k_1)}{\left[-(bs + k_1)^2 + (m_2 s^2 + bs + k_1 + k_2)(m_1 s^2 + bs + k_1) \right]}$$

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