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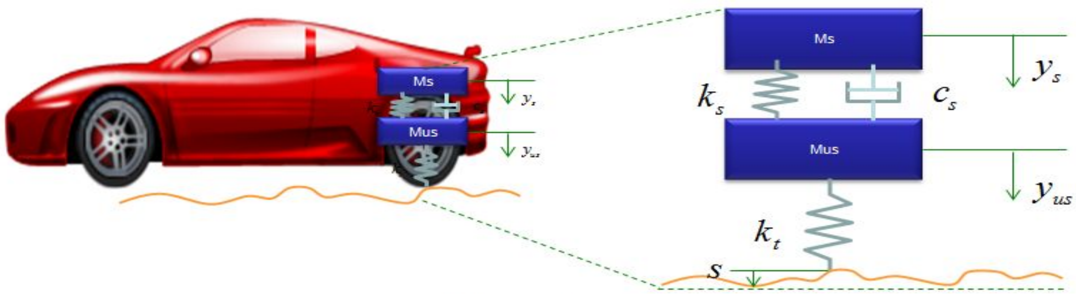
Experiment #07 - SPRUNG MASS DISPLACEMENT IN A QUARTER CAR (ONE WHEEL) MODEL

Aim: To write MATLAB code for system of second order differential equations of the form $X' + AX = 0$ using diagonalization. Determining the sprung mass displacement in a car suspension for one wheel. Solving a coupled system of ordinary differential equations derived from the mathematical model.

Mathematical Background:



The system shown in Figure. 1 is an quarter car system where,

M_s	is the sprung mass
M_{us}	is the unsprung mass
k_s	is the stiffness coefficient of the suspension
k_t	is the vertical stiffness of the tire
c_s	is the damping coefficient of the suspension
b_2	is the damping coefficient of the tire
y_2	the vertical displacement of sprung mass
y_{us}	is the vertical displacement of unsprung mass
s	is the road excitation

***Sprung mass equation in a quarter car (one wheel)*:**

$$M_s \frac{d^2 y_s}{dt^2} =- c_s\left(\frac{dy_s}{dt} - \frac{dy_{us}}{dt}\right) - k_s(y_s - y_{us}) = 0 \ldots(1)$$

Unsprung mass equation in a quarter car (one wheel):

$$M_{us}\frac{d^2y_{us}}{dt^2} =- c_s\left(\frac{dy_{us}}{dt}-\frac{dy_s}{dt}\right)-k_s(y_{us}-y_s)+k_t y_{us}=k_t s \ldots(1)$$

Matrix form of above equations:

$$\begin{bmatrix} M_s & 0 \\ 0 & M_{us}\end{bmatrix}\begin{bmatrix}\dfrac{d^2y_s}{dt^2} \\ \dfrac{d^2y_{us}}{dt^2}\end{bmatrix}+\begin{bmatrix} c_s & -c_s \\ -c_s & c_s\end{bmatrix}\begin{bmatrix}\dfrac{dy_s}{dt} \\ \dfrac{dy_{us}}{dt}\end{bmatrix}+\begin{bmatrix} k_s & -k_s \\ -k_s & k_s+k_t\end{bmatrix}\begin{bmatrix} y_s \\ y_{us}\end{bmatrix}=\begin{bmatrix} 0 \\ k_t s\end{bmatrix}$$

$$\mathbf{M}\ddot{\mathbf{y}}+\mathbf{c}\dot{\mathbf{y}}+\mathbf{k}\mathbf{y}=\mathbf{f}$$

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2\end{bmatrix}\frac{d^2}{dt^2}\begin{bmatrix} x_1 \\ x_2\end{bmatrix}+\begin{bmatrix}(k_1+k_2) & -k_2 \\ -k_2 & (k_2+k_3)\end{bmatrix}\begin{bmatrix} x_1 \\ x_2\end{bmatrix}=\begin{bmatrix} 0 \\ 0\end{bmatrix}$$

$$\mathbf{M}\frac{d^2\mathbf{x}}{dt^2}+\mathbf{K}\mathbf{x}=0$$

MATLAB syntax

`eig(A)`	Returns a vector of the eigenvalues of matrix A
`solve(eq,x)`	Returns the set of all complex solutions of an equation or inequality *eq* with respect to *x*.

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$$\begin{bmatrix} M_s & 0 \\ 0 & M_{us} \end{bmatrix} \begin{bmatrix} \frac{d^2 y_s}{dt^2} \\ \frac{d^2 y_{us}}{dt^2} \end{bmatrix} + \begin{bmatrix} c_s & -c_s \\ -c_s & c_s \end{bmatrix} \begin{bmatrix} \frac{dy_s}{dt} \\ \frac{dy_{us}}{dt} \end{bmatrix}$$

$$+ \begin{bmatrix} k_s & -k_s \\ -k_s & k_s + k_t \end{bmatrix} \begin{bmatrix} y_s \\ y_{us} \end{bmatrix} = \begin{bmatrix} 0 \\ k_t u \end{bmatrix}$$

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