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(* In Plane Motorcycle Dynamics *)
Rf = 2.1;      (*Ride Frequency*)
CofG = 0.62; (*CofG Forward Bias*)
Mass = 220;
Z = 0.6;      (*Zeta*)
p = 1.4; b = p * CofG;
Ip = 38;
USMf = 12; USMr = 15; US = {USMf, USMr};
Mf = CofG * Mass - USMf;

Mr = Mass - Mf - USMr - USMf;
Mf + Mr + USMf + USMr;
M = {Mf, Mr};
k = M * (2 * Pi * Rf) ^ 2;
Cc = 2 * Sqrt[k * M];
c = Z * Cc;

kf = k[[1]]; kr = k[[2]]; cf = c[[1]]; cr = c[[2]];

ktf = 150 000;
ktr = 130 000;
kt = {ktf, ktr};
K = (k * kt) / (k + kt);
Kf = K[[1]]; Kr = K[[2]];

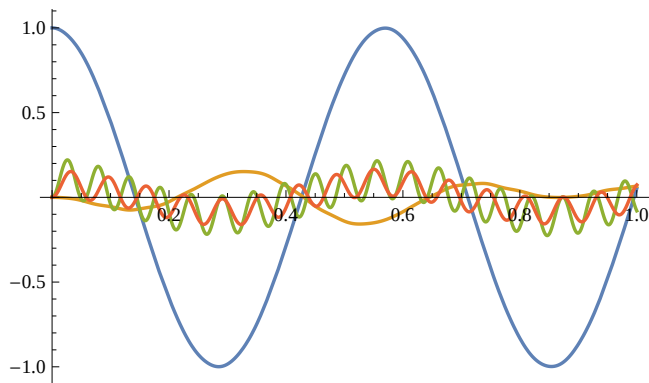
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$$\text{Response} = \begin{pmatrix} \text{Mass} & 0 & 0 & 0 \\ 0 & \text{Ip} & 0 & 0 \\ 0 & 0 & \text{USMf} & 0 \\ 0 & 0 & 0 & \text{USMr} \end{pmatrix} \cdot \begin{pmatrix} x''[t] \\ \text{Phi}''[t] \\ xf''[t] \\ xr''[t] \end{pmatrix} + \\
 \begin{pmatrix} Kf + Kr & Kf(p-b) - Kr*b & -Kf & -Kr \\ Kf(p-b) - Kr*b & Kf(p-b)^2 + Kr*b^2 & -(p-b)Kr & b*Kr \\ -Kf & -(p-b)Kf & Kf + ktf & 0 \\ -Kr & b*Kr & 0 & Kr + ktr \end{pmatrix} \cdot \begin{pmatrix} x[t] \\ \text{Phi}[t] \\ xf[t] \\ xr[t] \end{pmatrix};$$

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Dyn = NDSolve[{Response[[1]] == 0, Response[[2]] == 0, Response[[3]] == 0,
  Response[[4]] == 0, x[0] == 1, x'[0] == 0, Phi[0] == 0, Phi'[0] == 0,
  xf[0] == 0, xf'[0] == 0, xr[0] == 0, xr'[0] == 0}, {x, Phi, xf, xr}, {t, 0, 1}];
Plot[Evaluate[{x[t], Phi[t], xf[t], xr[t]} /. Dyn], {t, 0, 1}, PlotRange -> All]

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$$\text{Vib} = -\text{Mass} * \text{I} * \omega^4 + ((\text{I} + \text{Mass} * \text{b}^2) * \text{Kr} + (\text{I} * \text{Mass} * (\text{p} - \text{b})^2) * \text{Kf}) * \omega^2 - \text{p}^2 * \text{Kr} * \text{Kf} == 0$$

$$-4.05745 \times 10^8 + (1.81306 \times 10^6 + 1.18934 \times 10^6 i) \omega^2 - 220 i \omega^4 == 0$$

$$\text{Vibra} = \text{Roots}[\text{Vib}, \omega]$$

$$\omega == 13.2397 - 3.89753 i \mid \mid \omega == -13.2397 + 3.89753 i \mid \mid$$

$$\omega == 86.3953 - 47.0975 i \mid \mid \omega == -86.3953 + 47.0975 i$$

$$\text{zo} = \text{Kf} * (\text{p} - \text{b})^2 + \text{Kr} * \text{b}^2 - \text{I} * \omega^2$$

$$\text{Phio} = -\text{Kf} * (\text{p} - \text{b}) + \text{Kr} * \text{b}$$

$$13597.6 - i \omega^2$$

$$-573.86$$

$$\text{s} = \text{zo} / \text{Phio}$$

$$-0.00174258 (13597.6 - i \omega^2)$$