1st bead without 2nd.

$$\dot{R}_1 = -\mu_{11} K_1 (R_1 - R_1^0)$$

$$\dot{\Delta}_1 = -\mu_{11} K_1 \Delta_1 - \dot{R}_1^0$$

$$\dot{\Delta}_1 + \mu_{11} K_1 \Delta_1 = -\dot{R}_1^0$$

$$\Delta_1 = \left[-\frac{i\omega}{i\omega + \mu_{11} K_1} \right] R_1^0(\omega)$$

$$R_1(\omega) = \left[1 - \frac{i\omega}{i\omega + \mu_{11} K_1} \right] R_1^0(\omega)$$

$$= \frac{\mu_{11} K_1}{i\omega + \mu_{11} K_1} R_1^0(\omega)$$

As solution is $A e^{i\delta}$

$$\delta = \tan^{-1} \left[-\frac{\omega}{\mu_{11} K_1} \right]$$

$$\dot{R}_1 = -\mu_{11} K_1 (R_1 - R_1^0) - \mu_{12} K_2 (R_2 - R_2^0)$$

$$\dot{R}_2 = -\mu_{21} K_1 (R_1 - R_1^0) - \mu_{22} K_2 (R_2 - R_2^0).$$

$$\Delta_1 = R_1 - R_1^0$$

$$\dot{\Delta}_1 = \dot{R}_1 - \dot{R}_1^0 \longrightarrow$$

$$\Delta_2 = R_2 - R_2^0$$

$$\dot{\Delta}_2 = \dot{R}_2$$

$$\dot{\Delta}_1 = -\mu_{11} K_1 \Delta_1 - \mu_{12} K_2 \Delta_2 - \dot{R}_1^0$$

$$\dot{\Delta}_2 = -\mu_{21} K_1 \Delta_1 - \mu_{22} K_2 \Delta_2$$

2nd Bead

$$-\mu_{21} K_1 \Delta_1 = \dot{\Delta}_2 + \mu_{22} K_2 \Delta_2$$

$$-\mu_{21} K_1 \dot{\Delta}_1 = \ddot{\Delta}_2 + \mu_{22} K_2 \dot{\Delta}_2$$

$$\ddot{\Delta}_2 + \mu_{22} K_2 \dot{\Delta}_2 = -\mu_{11} K_1 \left[\dot{\Delta}_2 + \mu_{22} K_2 \Delta_2 \right]$$

$$+ \mu_{21} \mu_{12} K_2 K_1 \Delta_2 \quad + \mu_{21} K_1 \dot{R}_1^{\circ}$$

$$\Rightarrow \ddot{\Delta}_2 + \left(K_1 \mu_{11} + K_2 \mu_{22} \right) \dot{\Delta}_2 + K_1 K_2 \left(\mu_{11} \mu_{22} - \mu_{21} \mu_{12} \right) \Delta_2$$

$$= + \mu_{21} K_1 \dot{R}_1^{\circ}$$

$$\Delta_2 = \frac{i\omega \mu_{21} K_1}{\left(\omega_0^2 - \omega^2 \right) + i 2\lambda \omega} R_1^{\circ}(\omega)$$

$$2\lambda = \left(K_1 \mu_{11} + K_2 \mu_{22} \right)$$

$$\omega_0^2 = K_1 K_2 \left(\mu_{11} \mu_{22} - \mu_{21} \mu_{12} \right)$$

$$\delta_2 = \tan^{-1} \left[\frac{ad - bc}{ac + bd} \right] = \tan^{-1} \left(\frac{a}{b} \right)$$

$$= \tan^{-1} \left(\frac{\omega_0^2 - \omega^2}{2\lambda \omega} \right)$$

Solving for the first bead.

$\cancel{\Delta_2}$

$$-\mu_{12}k_2\Delta_2 = \dot{\Delta}_1 + \mu_{11}k_1\Delta_1 + \dot{R}_1^0$$

$$-\mu_{12}k_2\dot{\Delta}_2 = \ddot{\Delta}_1 + \mu_{11}k_1\dot{\Delta}_1 + \ddot{R}_1^0$$

$$\Rightarrow \ddot{\Delta}_1 + \mu_{11}k_1\dot{\Delta}_1 + \ddot{R}_1^0 = +\mu_{12}\mu_{21}k_1k_2\Delta_1 - \mu_{22}k_2 \cancel{x} \left[\dot{\Delta}_1 + \mu_{11}k_1\Delta_1 + \dot{R}_1^0 \right]$$

$$\Rightarrow \ddot{\Delta}_1 + (\mu_{11}k_1 + \mu_{22}k_2)\dot{\Delta}_1 + (\mu_{11}\mu_{22} - \mu_{12}\mu_{21})k_1k_2\Delta_1 = -\mu_{22}k_2\dot{R}_1^0 - \ddot{R}_1^0$$

$$\Delta_1 = \left[\frac{-i\omega\mu_{22}k_2 + \omega^2}{(\omega_0^2 - \omega^2) + i2\lambda\omega}\right] R_1^0(\omega)$$

$$R_1(\omega) = \left[1 + \quad \dots \right] R_1^0(\omega)$$

$$= \left[\frac{\omega_0^2 + i(2\lambda - \mu_{22}k_2)\omega}{(\omega_0^2 - \omega^2) + i2\lambda\omega}\right] R_1^0(\omega)$$

$$\tan \delta_1 = \frac{ad - bc}{ac + bd}$$

$$a = (\omega_0^2 - \omega^2)$$

$$b = 2\lambda\omega$$

$$c = \omega_0^2$$

$$d = (2\lambda - \mu_{22}k_2)\,\omega$$

Check in matlab code.