Harmonic Balance Method

Project #1

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**Format of Harmonic Balance Subroutine**

The subroutine for finding the harmonic balance response begins by creating a ‘sampled frequency’. This involves defining the number of samples the user wishes to take and creating a vector of evenly spaced positions in time. For this analysis, it was determined that we could guess an initial response function which is equal to the forcing function. Therefore *xbar* is set equal to the forcing function which is in turn a function of the time vector.

*N = 99*

*t = np.linspace(0, 10\*np.pi, N+1) # Time sample vector*

*t = t[0:-1] # Removing the extra sample*

*f = np.cos(2\*t) # My forcing function*

*T = t[-1]*

*xbar = f #Initial guess of the response function*

The second step in the analysis is to put the response function into the form of a periodic response using fast Fourier transforms and to calculate the remainder, *R*, when the results are plugged into the original differential equation. This step is incorporated into a subroutine within the process.

*def FUNCTION(xbar):*

*N = len(xbar)*

*Xbar = np.fft.fft(xbar) #Calculate the fft of xbar*

*omega = np.fft.fftfreq(N, T/(2\*np.pi\*N) ) # list of frequencies*

*dotxbar = np.fft.ifft(np.multiply((1j\*omega),Xbar)) #Calculate the derivative of xbar*

*dotdotxbar = np.fft.ifft(np.multiply((1j\*omega)\*\*2,Xbar)) #Calculate the derivative again*

*R = dotdotxbar + dotxbar + xbar - 0\*xbar\*\*3 – f #Substitute into original eqn*

*R = R\*\*2*

*R = np.sum(R) #Calculate the remainder*

*return R*

After the function calculating the remainder has been defined, it can be inserted into a ‘minimize’ function and optimized with respect to the response function. The results of this minimize function are the output of the harmonic balance method.

*optimizedResults = sci.minimize(FUNCTION, xbar, method='SLSQP')*

*xbar = optimizedResults.x*

*print(optimizedResults)*

*print(xbar)*

*pl.scatter(t,xbar)*

*pl.show()*

**Results**

For this project, three functions were evaluated with the harmonic balance function defined above.













