Tim Coon

# MECH719 Qual Exam Question Responses

1. What is the significance of the unknown initial condition? How did this affect the way you processed data?

   The unknown initial condition is significant to producing a time-domain simulation. All of the questions asked are answered using frequency-domain analysis, thus, the unknown initial condition did not affect the processing of data.

2. What is the value of $k$? $k = 10$ N/m

   The state-space model of the system was derived and the FRF was simulated using a guessed value for $k$ ($c = 0$). The value of $k$ was then adjusted manually until the resonant peaks of the measured data and the simulation lined up at the same frequencies. The resonant frequencies are close to the natural frequencies and the natural frequency is solely dependent on k because the mass is fixed and known.

3. What is the value of $c$? $c = 0.6$ N-s/m

   Using the state-space model and $k = 10$ N/m, the FRF was simulated and compared to the measured data. The value of $c$ was adjusted until the slopes and heights of the peaks were similar. It is possible to use a log-decrement or half-power method to find the damping ratio from the measured data FRF and then calculate the damping coefficient.

4. What type of measurement is $x_1$?

   Measurement, $x_1$, is the velocity of mass one. This is evident by comparison of the simulated FRF for velocity output and the measured data FRF. The figure shows simulated position, velocity, and acceleration transfer functions for complete comparison.

5. What type of measurement is $x_2$?

   Measurement, $x_2$, is the position of mass two. This is evident by comparison of the simulated FRF for velocity output and the measured data FRF. Notice that the phase of the measured data jumps 360 degrees at 0.5 Hz, but this is equivalent.

6. Was five samples per second adequate to measure the dynamics of this system or should a slower or faster sample rate be used?

   Five samples per second was an adequate rate. The nyquist frequency is 2.5 Hz and the second mode occurs around 0.9 Hz, so there is no aliasing effect. A slightly slower sample rate could be used if necessary. The duration of the sampling allowed for the separation into two sets for averaging to improve appearance of the FRFs. A running average could also be implemented and might reduce the need for a longer sampling time.

7. Using your determined values of $k$ and $c$, compare the measured mode shapes (obtained from the FRFs) to the theoretical mode shapes?

   Mode shapes of simulated second-order model are the eigenvectors. These are plotted and show the first mode shape with both masses displaced in the same direction and the second mode shape with the masses displaced in opposite directions.

   The measured data came as one velocity and one position measurement. Velocity is integrated in the frequency domain by dividing $j\omega_i$ at each frequency and the position FRF is readily obtained from the measured velocities. Mode shapes are determined using the magnitude of the FRF at the resonant frequencies modified by the sign of the cosine of the phase at the respective frequencies. Mode shape 1 shows the masses moving in-phase while mode shape 2 shows them out-of-phase, as expected from the theoretical model. The relative sizes of the eigenvector elements are similar (see below) and the marginal deviation is attributed to imperfect data collection.

$$V1_{calc} = \begin{matrix} 1.0 \\ 2.2 \end{matrix} \qquad V2_{calc} = \begin{matrix} 1.0 \\ -0.2 \end{matrix}$$

$$V1_{meas} = \begin{matrix} 1.0 \\ 1.9 \end{matrix} \qquad V2_{meas} = \begin{matrix} 1.0 \\ -0.2 \end{matrix}$$