## Intro

* Purpose
  + Analyze different causes of harmonic response of second order systems

## Experiment 1: Sine Sweep Tests

Procedure overview

* + use the 1st carriage with the thickest spring and only the carriage’s own mass
  + Thickest spring bw 1st carriage and vertical support
  + Set prescribed damping and stiffness using software
  + Configure sine-sweep signal with given amplitude (four tests at four amplitude levels) from 1 Hz to 10 Hz frequency range within 40 seconds

Step by step

1. Physical setup: configure the system with the thickest spring attached between the first carriage and the motor. We will not use any of the mass blocks for these tests, and only consider the carriage’s own mass.
2. Software stiffness and damping: to provide an (Additive) damping and stiffness from the software, click on the Configuration tab.
   * Set the spring constant to 200 N/m.
   * Set damping coefficient to 2 Ns/m
3. Averaging
   * to reduce the effect of noise, we will consider 2 averages for each case. However for one case, we will (separately) perform 5 and 2 averages to evaluate whether the noise level is decreased by further averaging. In the Configuration tab Averaging section, set the *Runs to Average* to the value given in Table 1 for each test. Make sure *Averaging noise data?* Check box is NOT checked
4. Forcing function setup
   * Go back to Time tab
   * Click Configure and select Sweep Sing from list of forcing functions
   * For each test, set the amplitude according to Table 1
   * Duration: 40 s. Sample rate: 1000 Hz
   * Starting frequency Fstart = 1 Hz
   * Ending frequency Fend = 10 Hz and Repeat to 1
   * All other parameters set to 0
5. Conducting the Experiment
   * Go to the FRF tab on the main program
   * First click Reset to reset the encoders. Then click Run to execute the swept sine input.
   * Once the run is completed, and the programs return to IDLE.
   * First select the Frequency by clicking on the button below the Save button, then click Save to save your data.
   * You should select FRF Magnitude 1 and FRF Phase 1. This will save the average FRF you obtained. NOTE YOUR OBSERVATIONS.
6. Follow the same procedure for each of the rows of Table 1.

Table 1: The parameters that will be used during the Sine Sweep test

|  |  |  |
| --- | --- | --- |
| Test | Amplitude | Averages |
| 1 | 0.65 | 2 |
| 2 | 1 | 2 |
| 3 | 1.25 | 2 |
| 4 | 1.25 | 5 |
| 5 | 1.5 | 2 |

Table 1: the parameters that will be used during the Sine-Sweep tests

## Experiment 2: Random Tests

Procedure:

In these tests, we will use the first carriage with the thickest spring and with only the carriage’s own mass. To perform the test, we will first complete the physical setup by attaching the thickest spring between the first carriage and vertical support. We will then set prescribed stiffness and damping coefficients through the software. Subsequently, we will configure a Random signal with the given amplitude (two such test at different amplitudes) from 1 Hz to 10 Hz within 40 seconds. Each test however will be averaged over 10 sets of tests, totalling 400 s. As a result, the software will provide the FRF’s and associated coherence plots.

1. Physical Setup (this physical setup is the same as above). Configure the system with the thickest spring attached between the first carriage and the vertical support located between the first carriage and the motor. We will not use any of the mass blocks for these tests, and only consider the carriage’s own mass.
2. Software stiffness and damping: (stiffness and damping are the same as above). To provide an (additive) damping stiffness from the software, click on the Configuration tab. Set the Spring Constant to 200 N/m. Specify the Damping coefficient as 2 Ns/m.
3. Averaging: to reduce the effect of noise, we will consider 10 averages for each case. On the Configurations tab Averaging section, set the Runs to Average to 10. Make sure *Averaging noise data?*  IS checked.
4. Forcing function setup:
   * Go back to *Time Domain* tab
   * Click *Configure*, and select *Noise* from the list of forcing functions.
   * Forcing each test, set the *Amplitude* according to Table 2.
   * Set the *Duration* to 400 s, *Sample rate* to 1000 Hz.
   * Starting frequency *Lower Frequency* to 1 Hz.
   * Ending frequency *Higher frequency* to 10 Hz
   * *Repeat*  to 2.
   * All other parameters set to 0.
5. Conducting the Experiment
   * Go to the FRF tab on the main program
   * First click *Reset* to reset the encoders
   * Then click *Run*  to execute the random input. On the run is completed, the program returns to IDLE.
   * First **select the Frequency by clicking on the button below the Save button**, then click *Save* to save all your data.
   * Us *FRF Magnitude 1* and *FRF Phase 1.* This will save averaged FRF you obtained. NOTE OBSERVATIONS
6. NOTE: for the random excitation, the software considers the duration as the total duration of averages (in this case 10)

|  |  |
| --- | --- |
| Test | Amplitude (N) |
| 1 | 10 |
| 2 | 15 |

## Experiment 3: The effect of dynamic parameters on the FRF

Procedure:

Physical setup: attaching the thickest spring between the first carriage and the veritcal support. In the first 7 tests, only carriages own mass is considered. For the last two tests, mass block will be added to evluate the effect of added mass. In addition to the thickest spring and inherent damping coefficient, in many of the tests, spring rate and dampign coeffiients are varied throughout the software. Each tests will be conducted using Sine-Sweep type excitation forces with 1.2N amplitude, 2 averages, 1 Hz to 10 HZ frequency range, and 40 second duration (For each average)

1. Physical setup: same as above
2. In addition to the thickest spring and inherent damping coefficient, we will provide software stiffness and damping. To provide an additive damping and stiffness from the software, click on the Configuration tab, set the spring constant and damping coefficient according to Table 2.
3. Averaging: to reduce the effect of noise, we will consider 2 averages for each case. On the Configuration tab, Averaging section, set the Runs to Average to 2. Make sure *Averaging noise data?* Box is NOT checked.
4. Forcing function setup: go back to Time Domain tab. Now click Configure and select SWept Sine from the list of forcing functions. For each test, select Amplitude =1.2 N, Duration = 40 s, Sample rate = 1000 Hz, F start = 1 Hz, F end = 10 Hz, Repeat = 1.
5. Conducting the Experiment: Now go to the FRF tab on the main program, first click Reset to reset the encoders. Then click Run to execute the Sweep Sine input. Once the run is completed, and the program returns to IDLE, first select the Frequency by clicking on the button below the Save button, then click save your data. This will save the average FRF you obtained. `
6. Follow the same procedure for each of the rows of Table 3.

|  |  |  |  |
| --- | --- | --- | --- |
| Test | Added Spring (N/) | Added Damping (Ns/m) | Mass |
| 1 | 200 | 1 | - |
| 2 | 200 | 2 | - |
| 3 | 200 | 8 | - |
| 4 | 200 | 15 | - |
| 5 | 200 | 35 | - |
| 6 | 100 | 2 | - |
| 7 | 0 | 2 | - |
| 8 | 0 | 2 | Two large |
| 9 | 0 | 2 | All four |

## Experiment 4: Single frequency excitation tests

Procedure : We’ll use the same physical spring and the first carriage’s own mass. For all tests, a sinusoidal excitation force will be used with a 1.2N amplitude and for a 40s duration. A software stiffness of 200 N/m and a software damping of 2Ns/m will be used.

1. Physical setup: same as before. No blocks.
2. Providing software stiffness and damping in addition to spring and inherent damping.
3. Averaging: Runs to Average =1, Averaging noise data? NOT CHECKED
4. Forcing function setup: select Sine, amplitude = 1.2, duration = 40s, sample rate = 1000 Hz, frequency according to Table 4, repeat to 1.
5. Conducting the experiment: Time tab → click Reset, then click Run, once the run is completed and the program returns to IDLE first select the Time by clicking on the button below the Save button, then click SAve to save your data in the time domain. You should select Force and Displacement 1.

|  |  |
| --- | --- |
| Test | Frequency |
| 1 | 3 |
| 2 | 5 |
| 3 | 5.7 |
| 4 | 7 |

Note: go to class to see the Matlab tutorial for this?

## Experiment 5: Fourier Series Expansion

Procedure: same setup. For the 1st five tests in Table 5, we’re going to use Equation 9 with one additional term each time. Software stiffness = 200 N/m, and software damping = 2 Ns/m.

1. Physical setup -
2. In software, Spring constant = 200 N/m, damping = 2 Ns/m
3. Forcing function: triangle forcing
   1. Click Configure, select Ramp
   2. Slope = 16 N/s, duration = 0.5 s, Sample Rate = 1000 Hz
   3. **Mirrored and two sided check boxes should be checked. See screenshot**

Table 5: Parameters that will be used for the last five tests of Experiment 5