Assignment 1
A Study of An Experimental SDOF System I

Purpose:	An experimental structure that can be approximated as single-degree-of freedom system will be studied.
Preparation:	Study chapter 5 and 7 in '**Introductory Noise and Vibration Analysis**'.
Equipment:	Cantilever Beam Accelerometer and cable Impulse Hammer and cable National Instrument device, NI USB-9162
Software:	Matlab
Computer (Windows)	A Laptop is provided in the Lab. However, you are welcome to use your own Laptop. You require National instruments drivers (NIDAQ960f0) and Data Acquisition tool box in Matlab.
Latest Submission date:	**T.B.D (Announced on "itslearning")**

Problem Description

A simple dynamic systems which can be estimated as a single-degree-of-freedom (SDOF) system will be studied. The testrig consist of a mass connected at the end of a cantilever beam as shown in Figure 1.

Figure 1. *The experimental setup*

We will assume that the vibrations are small and that the dynamic behaviour in this mechanical system can be sufficiently described with a SDOF model as shown in Figure 2.

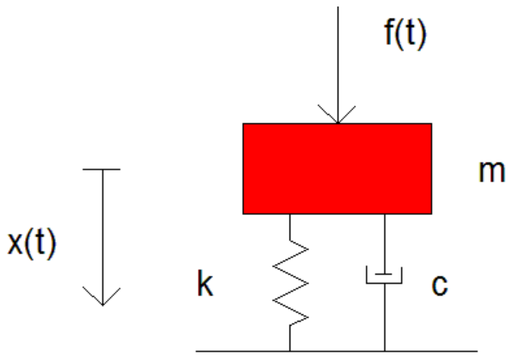

Figure 2. *A single-degree-of freedom system*

The equations of motions for this system can be written as:

$$\mathbf{m} \cdot \ddot{\mathbf{x}}(\mathbf{t}) + \mathbf{c} \cdot \dot{\mathbf{x}}(\mathbf{t}) + \mathbf{k} \cdot \mathbf{x}(\mathbf{t}) = \mathbf{f}(\mathbf{t}) \tag{1}$$

Your task is to measure the force and the acceleration from the experimental system. Frequency Response functions and other quantities will then be calculated.

Experimental Work

First, connect your impulse hammer to the data acquisition unit, **channel Ai0**. Then mount the accelerometer under the mass and connect it to **channel Ai1**. Plug in the USB-unit to the computer and start MATLAB.

Figure 3. *The data acquisition unit*

To acquire data in MATLAB, use the "matlab_help.pdf" document available in the Labs folder on "itslearning".

Use sampling frequency **Fs = 2000 Hz.**
The data will be acquired in units of volts. Select a proper **N** based on the acquired data. The measurement time (vector) may be given by **T=N/Fs** seconds.

Make sure that the impulse hammer is equipped with the black tip. Then do the following:

1) Set the measurement time to 40-60 seconds.
2) When MATLAB is acquiring data, hit on top of the mass with a light but distinct strike. Then wait for the response to decay.
4) Create a time vector for your signals and study the results, then save your data.

Repeat this 5 times. You should have five independent sets of measurements each containing the force signal and the response signal.

Check and document the sensitivity on the impulse hammer and the accelerometer as you will use this to convert your voltage signals to force/acceleration.

The weight of the mass connected to the beam = ***will be given in the Lab***.

Matlab Work

Task 1. Experimental Data.
Use the sensitivity to calculate the force [N] and the acceleration [m/s^2] from your voltage signals. Do this for all five measurements.

Select one measurement and plot the acceleration (m/s^2) and the force (N) in the time domain.

Task 2. Natural Frequency
Study the acceleration signals in the time domain and estimate the dominating natural frequency. Do this for each measurement and show the results in a table.

Task 3. Frequency Response Functions I
Estimate the frequency response function (*accelerance*) of the system.
Use the MATLAB function **fantransc** to calculate the spectra of each signal. Divide the acceleration spectrum with the force spectrum for each measurement. Then calculate the average value, as shown in Equation (2) for five measurements.

$$H_a(f) = \frac{1}{5} \cdot \sum_{n=1}^{5} \frac{A_n(f)}{F_n(f)} \qquad (2)$$

Plot the real part and the imaginary part of the transfer function from 5-100 Hz.

Task 4. Frequency Response Functions II
Calculate the receptance and the mobility using the frequency response function obtained in Task 3. Plot the magnitude of *Flexibility*, *Mobility* and *Accelerance* in the same figure (between 5-100 Hz).

Compare with Figure 2.4 in "Introductory Noise & Vibration Analysis". Can you see any similarity? Comment on the difference.

Task 5. Resonance Frequency & Damping
Study the *Flexibility*. Find the resonance frequency and the relative damping. Use the 3dB-Bandwidth method to calculate the relative damping.

Task 6. Stiffness & Damping
Use the formulas below and the result from Task 5 to estimate the stiffness (**K**) and the viscous damping (**C**). The value on **M** is given from the experiment.

$$w_0 = \sqrt{\frac{K}{M}}\ ,\ \zeta = \frac{C}{2 \cdot \sqrt{M \cdot K}}$$

Task 7. Stiffness & Damping
Use your parameters on M, C and K to calculate the analytic transfer function. Do this for *Flexibility*, *Mobility* and *Accelerance*.

Create one figure where you plot measured and analytic *Flexibility*, measured and analytic *Mobility* and measured and analytic *Accelerance*. Comment on the result.

Task 8. Nyqvist Diagram
Use the mobility to produce a Nyqvist diagram. Do this for both *measured mobility* and *analytic mobility* and then plot them in the same graph.

Task 9. Conclusions
Reflect on the results from all the tasks above. Is it a good approximation to describe the experimental structure as a Single-degree-of freedom system? Give some suggestions on how the theoretical model can be improved.

Report
A short and well written technical report shall be produced. **Use the Template at the hompage!**

Submission
Use It's Learning to submit your report. Go to folder Assignment 2010/Submission. Then click on 'A1 submission' and upload your report (before the deadline).

Good luck!