MASTER OF SCIENCES - BIOMEDICAL ENGINEERING

FINITE ELEMENT

ASSIGNMENT 4 – RESONANCE FREQUENCY

The objective of this assignment is to calculate the resonance frequency of an object using different numerical methods. Consider a beam (L=150mm, h=2.5mm, b=20mm, E=10GPa, v=0.3, ρ=7.0E3kg.m^{-3}) attached to a wall.

The resonance frequencies (inducing a bending in the direction of the dimension h) of such a model are given by the formula:

$$\frac{1}{2\pi\sqrt{12}}\alpha_i^2\sqrt{\frac{E}{\rho}}\frac{h}{L^2}$$

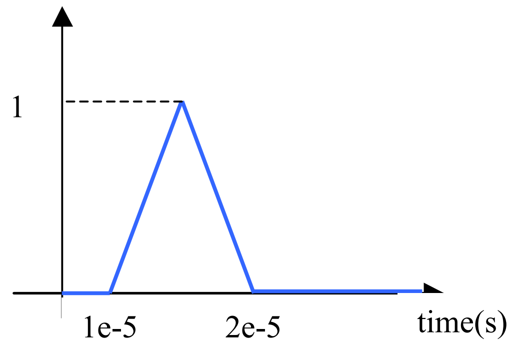
Where $\alpha_0 = 1.875, \alpha_1 = 4.695, \alpha_2 = 7.85, \ldots, \alpha_i = (2i+1)\frac{\pi}{2}$ for $i > 2$

1. Using the frequency mode in the FE software package, calculate the first resonance frequency of the model. Compare it to the analytic solution. Do **number** and **quality of elements** have an influence on the results? Give a **FEW** examples to illustrate.
   - Build your model as 2D->deformable->shell
   - Make sure the units of your material model are correct (if you use mm's, you should input MPa for E; and tonnes/mm^3 for ρ)
   - Create your instance in assembly as usual
   - In step, select "Linear Perturbation" as procedure type; then select "Frequency". In the menu, select "No of eigenvalues requested" and input a number.
   - In the BCs, simply encastre one side of the beam
   - Run the analysis

FEM offers another way to calculate that frequency. One can apply an impulse on the model and study its effect on the structure. Then extract the frequency of the vibration induced by this impulse

- Keep the same model (make sure you use 2D mesh).
- Change the element type to Explicit.
- Replace the step by a Dynamic, Explicit analysis. (Step->Procedure Type:General)
- In field output request, select frequency as "Every x units of time" and input 0.02. This will allow you to get outputs every 0.02 s.
- Apply an impulse load – with an amplitude curve described by the figure below – on the extremity of the bar. Orientate this load in the direction of the vibration you should study.
  - Amplitudes->Tabular->Create the amplitude curve in the figure
  - Loads->Concentrated force->Input your values and select your amplitude
- In the BCs, simply encastre one side of the beam

- Give the curve of the vibrations of the bar with time (you do not have to comment on it).
    - Select XY-Data-> Field Output-> save and plot U over time (select the node you applied the force)



- Save the values in a file and use the following commands in matlab (or octave) to extract the frequency of the signal:
    - a=load('frequency.txt');
    - y=fft(a(:,2));
    - m=abs(y);
    - freq=(0:length(y)-1)*50/(length(y)-1);
    - plot(freq(1:25),m(1:25,1))

  Give the plot obtained and extract the resonance frequency out of this graph. What can be the advantage of this method over the other one?

Annexe

The fft commands in matlab (octave) gives the Fourier transform of a signal. This transform gives the spectrum of its frequency components. In our case, we use a certain type of fourier transform called "finite" as we only work with a finite number of points on the curve.

Deadline: May 1st, 2016 (can.goekgoel@istb.unibe.ch)