RIYA Week 3 Presentation

Dynamics of 2-Spring Stack with Base Displacement

Jacob Thomas Sony
IIT Bombay

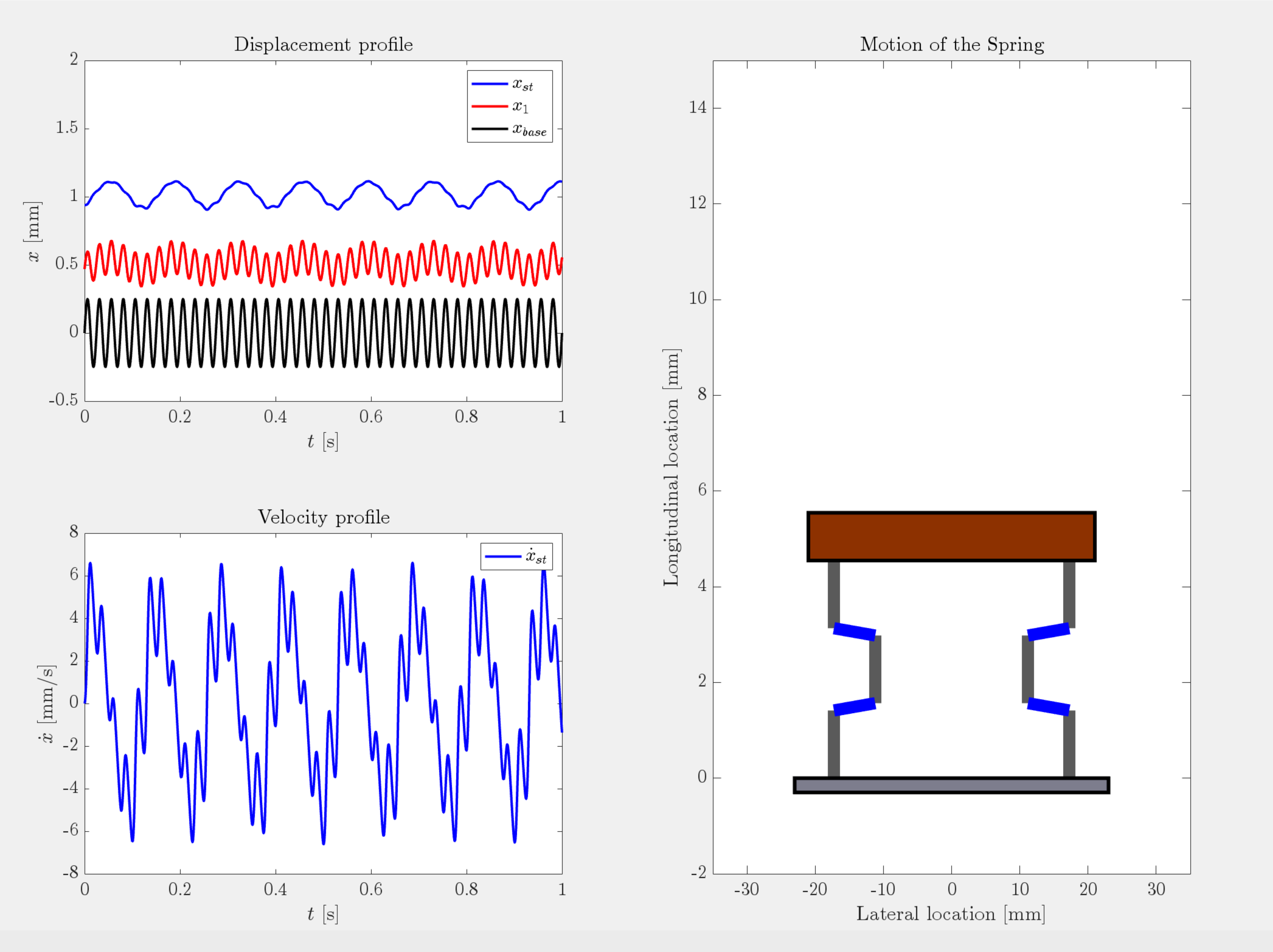
Objective

- To simulate the dynamics of a 2-spring stack in the presence of base excitation, and study the response in the time and frequency domains

Tasks accomplished

- Solved for static equilibrium of the system initially
- Incorporated sinusoidal base excitation into the simulation
- Performed FFT analysis of the acceleration data obtained
- Superimposed the Force-displacement curve on the static force-deflection curve

System response with Base Excitation



In the figure to the left, the top spring is denoted as spring 1 and the bottom spring is denoted as spring 2

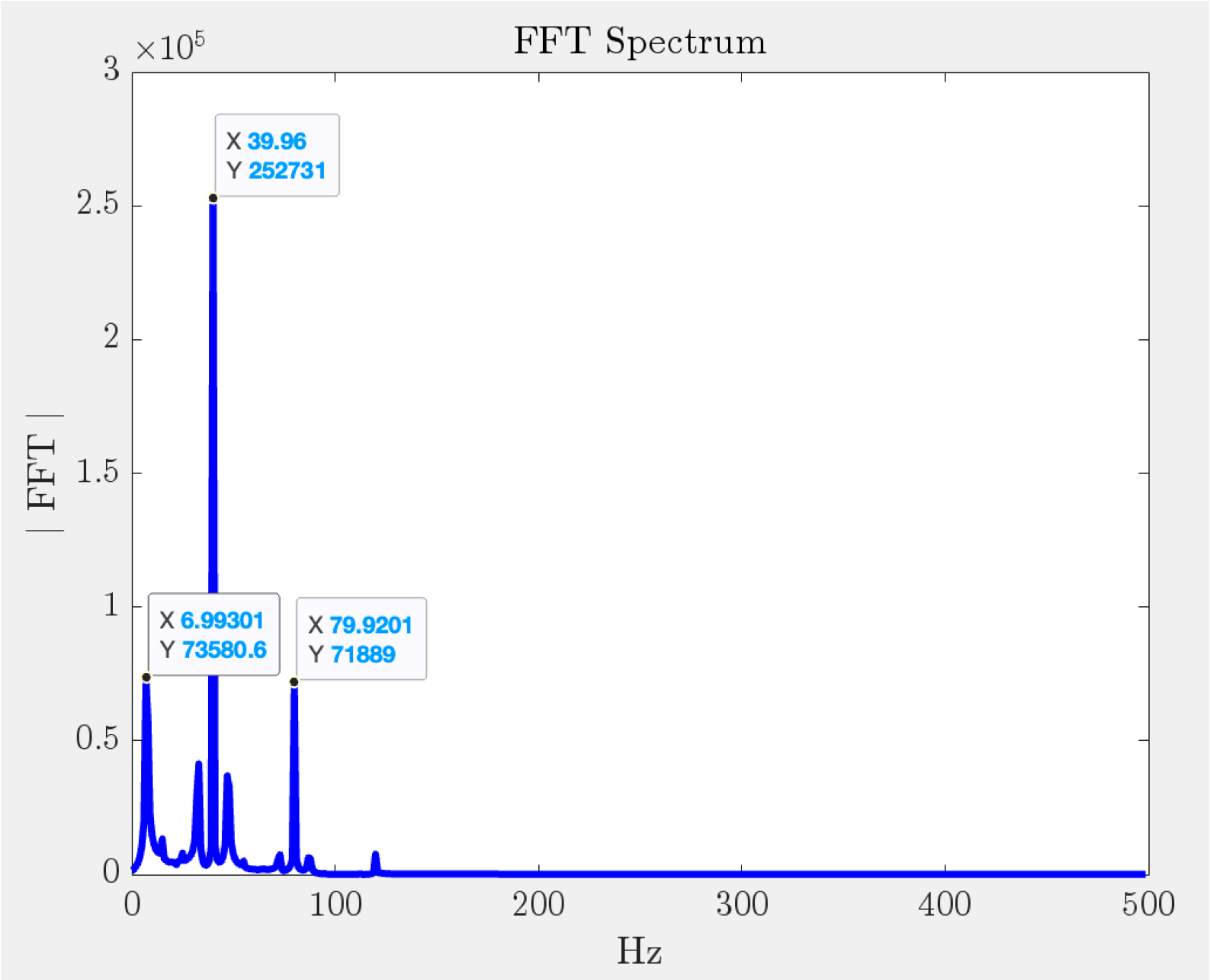
Height/Thickness of spring 1 = $\dfrac{h_1}{\tau} = 1.41$

Height/Thickness of spring 2 = $\dfrac{h_2}{\tau} = 1.41$

The base displacement (in mm) is given by $x_{base}(t) = 0.25\sin(80\pi t)$ so the frequency of excitation of the base is **40 Hz**

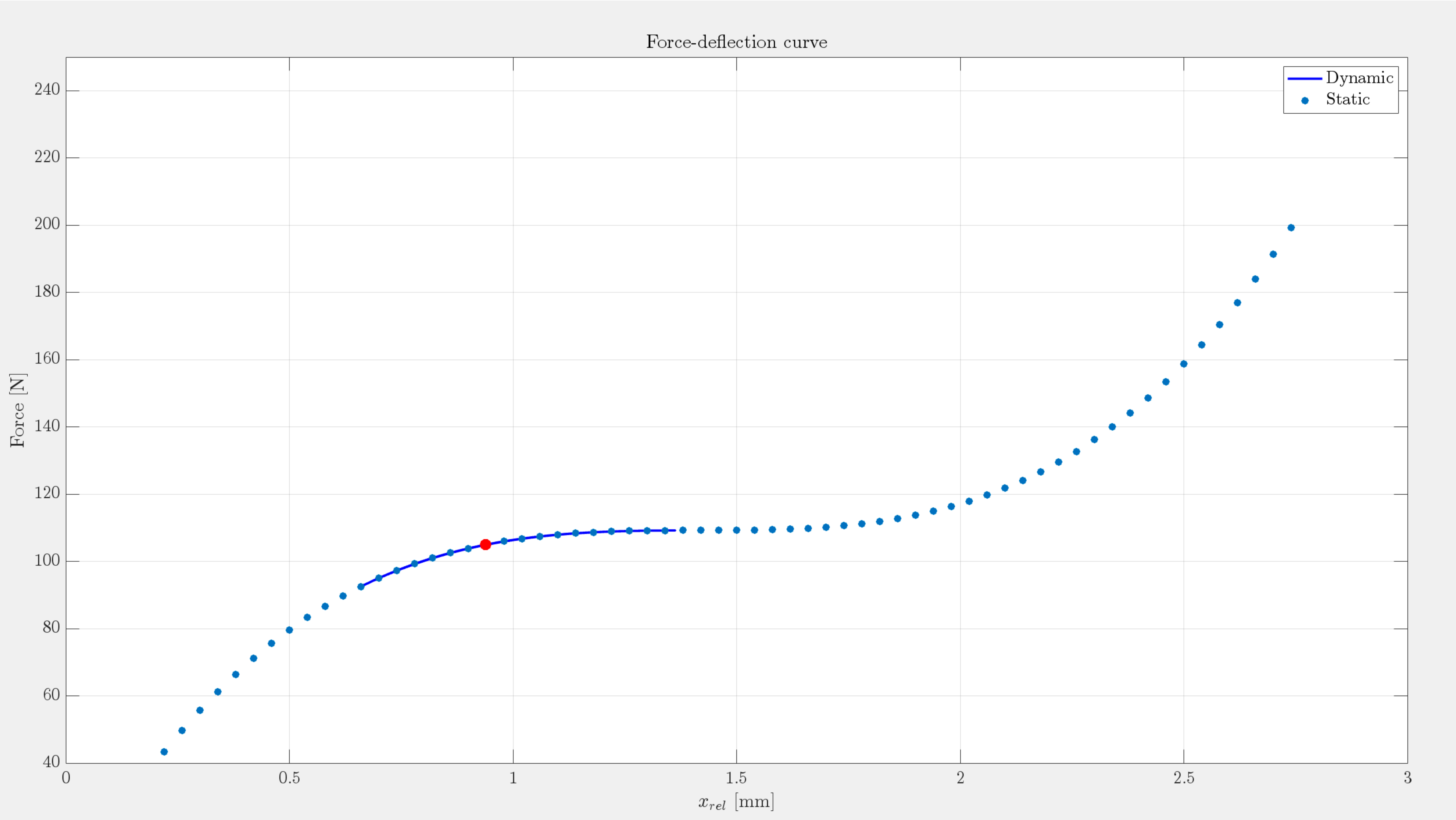
x_{st} and x_1 are the displacements of the top and bottom of spring 1 respectively

FFT Analysis



Case : $\frac{h_1}{\tau} = 1.41, \frac{h_2}{\tau} = 1.41,\ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

Plotting on static Force-deflection curve

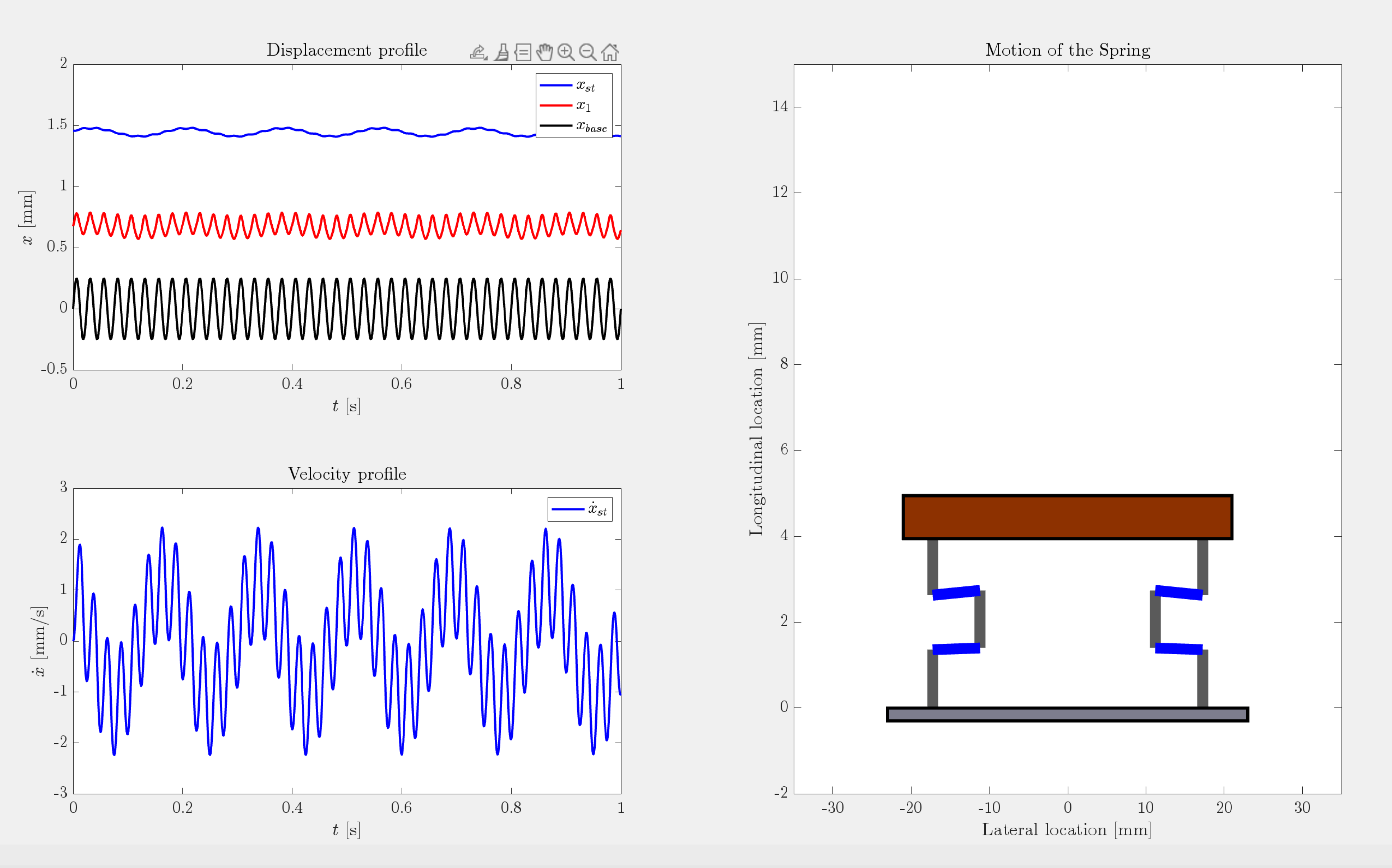


x_{rel} is the relative displacement between the top of spring 1 and the base.

In the **static** case, $x_{rel} = x_{st}$ (as $x_{base} \equiv 0$)
In the **dynamic** case $x_{rel} = x_{st} - x_{base}(t)$

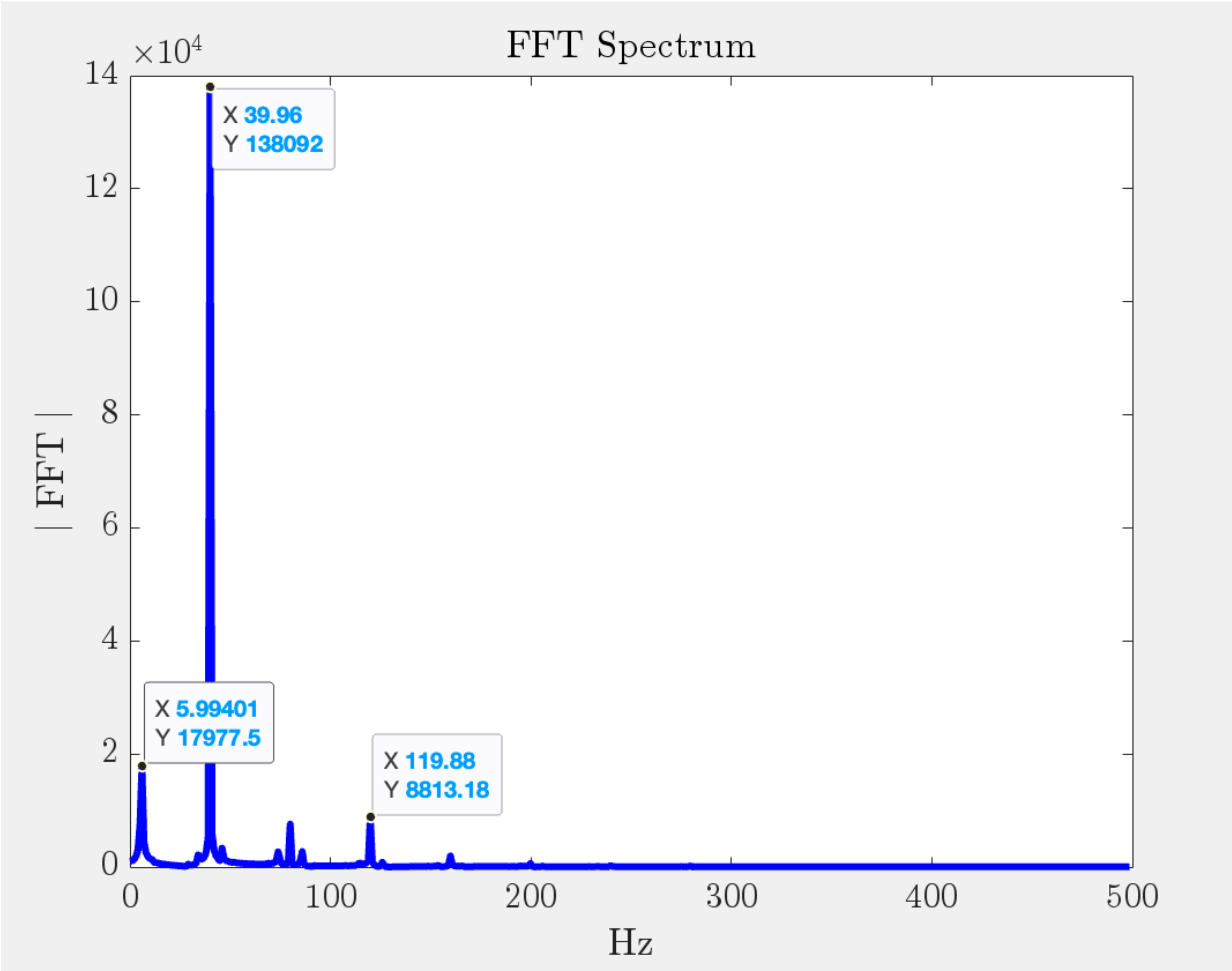
Case : $\dfrac{h_1}{\tau} = 1.41, \dfrac{h_2}{\tau} = 1.41,\ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

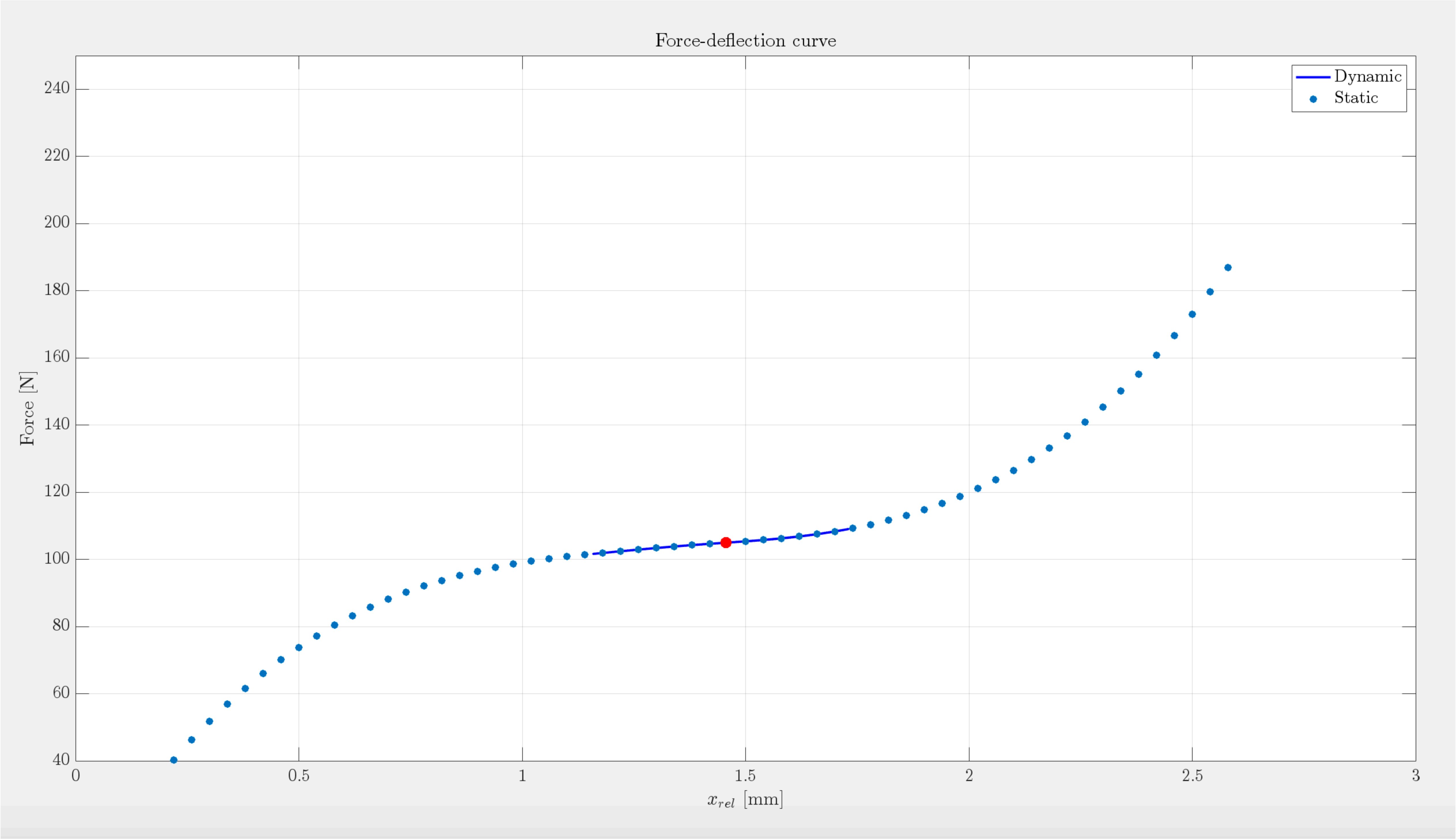
Other examples



Case : $\dfrac{h_1}{\tau} = 1.32, \dfrac{h_2}{\tau} = 1.36, \ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

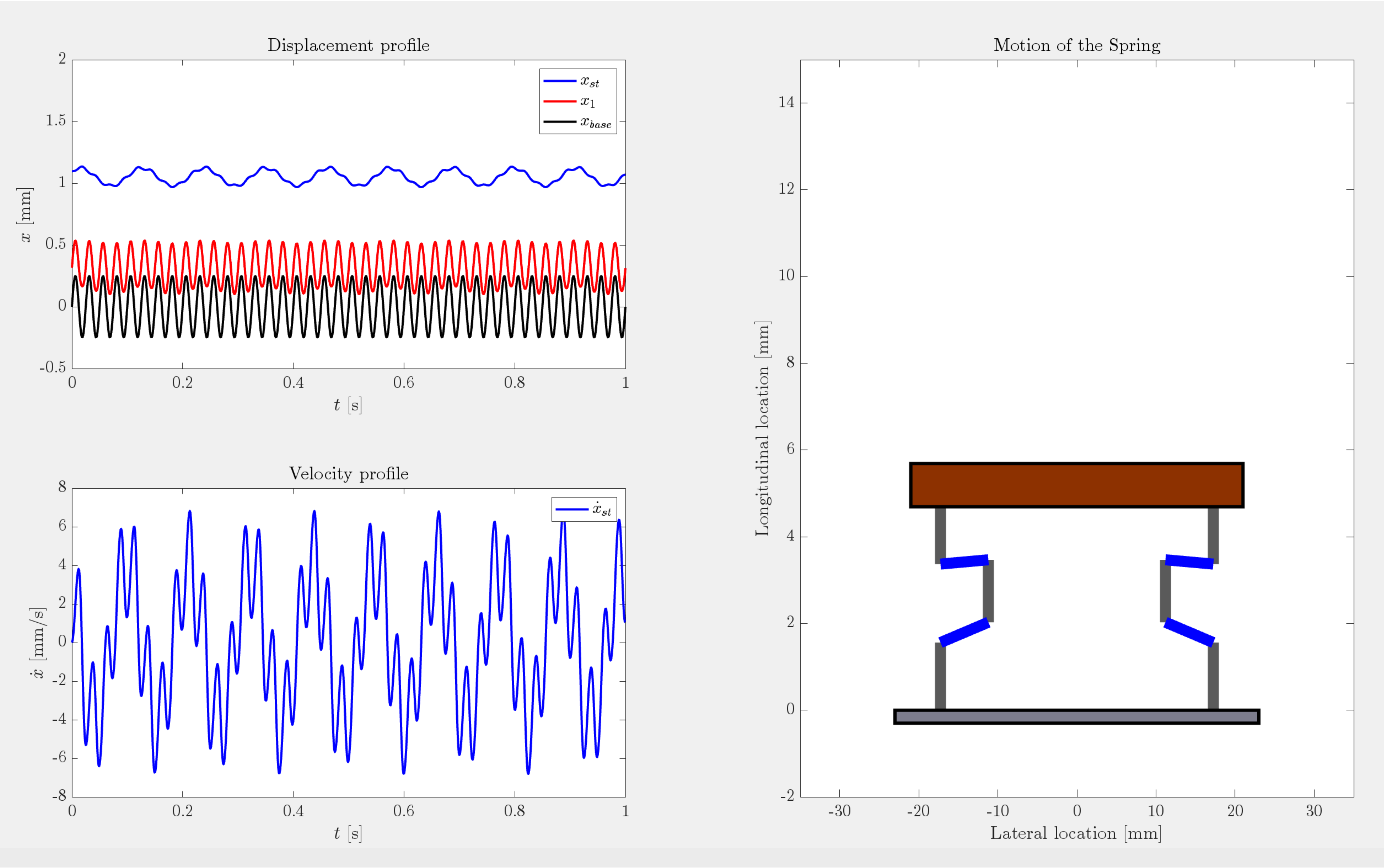
Other examples





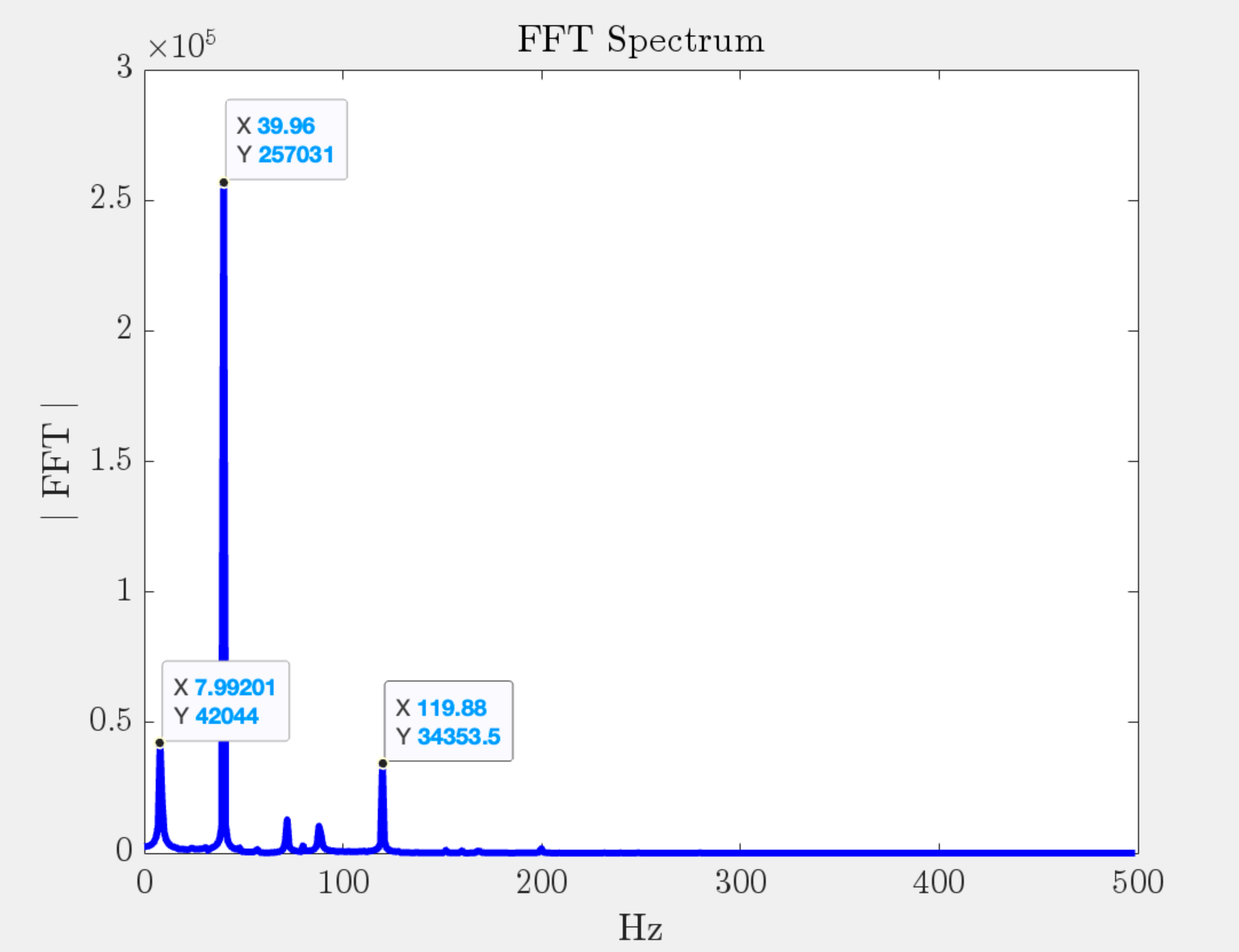
Case : $\dfrac{h_1}{\tau} = 1.32, \dfrac{h_2}{\tau} = 1.36, \; x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

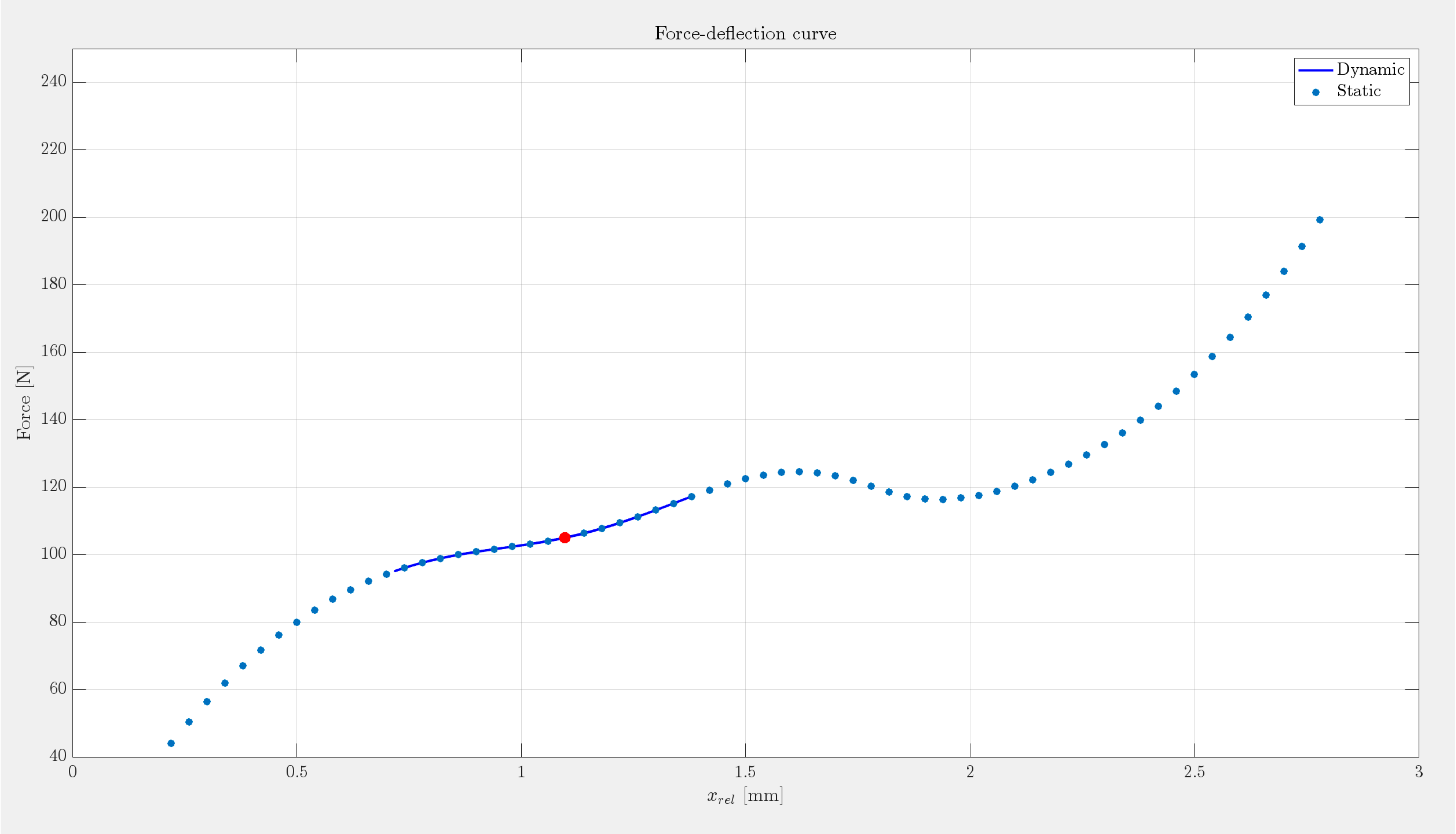
Other examples



Case : $\dfrac{h_1}{\tau} = 1.36, \dfrac{h_2}{\tau} = 1.58,\ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

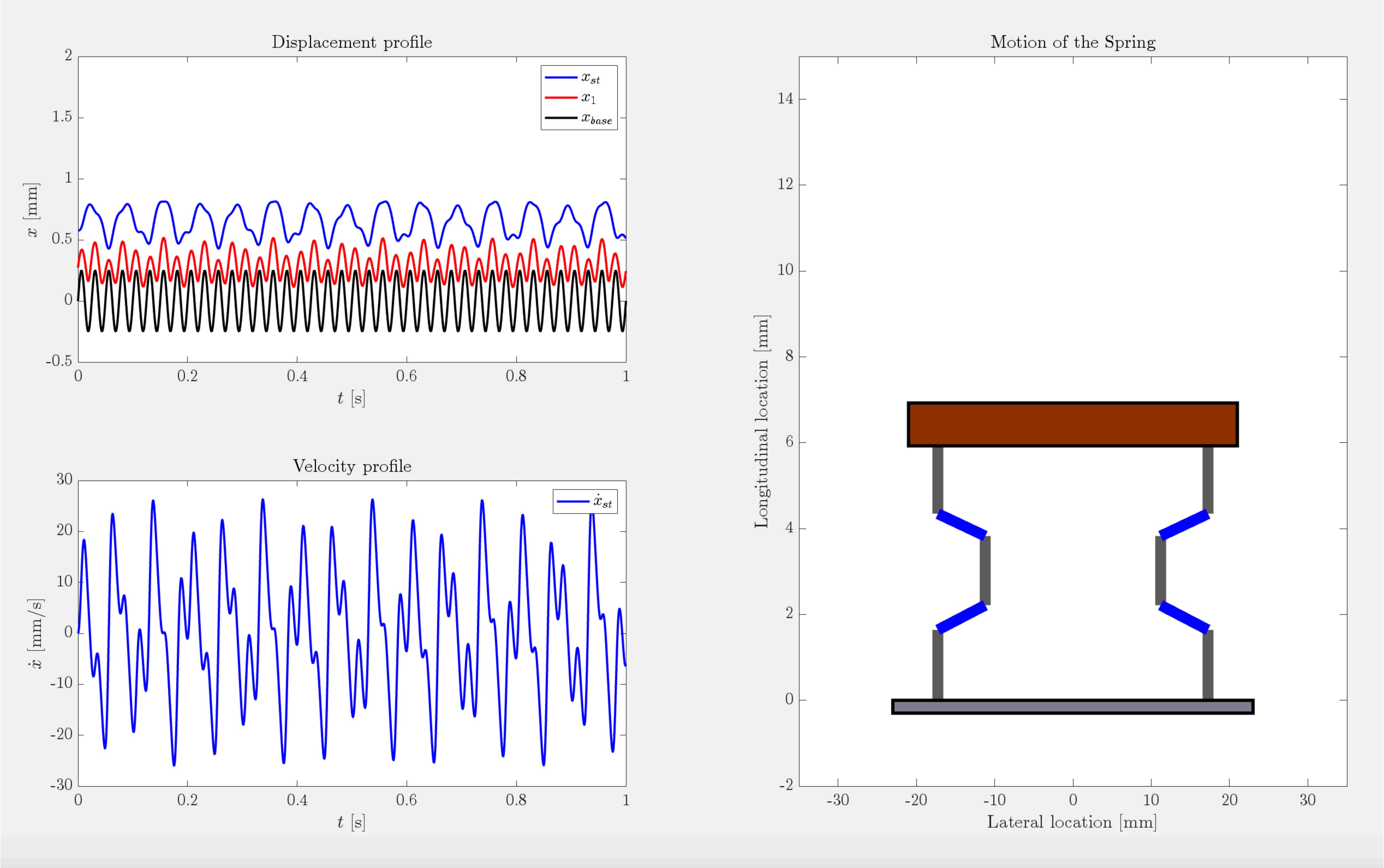
Other examples





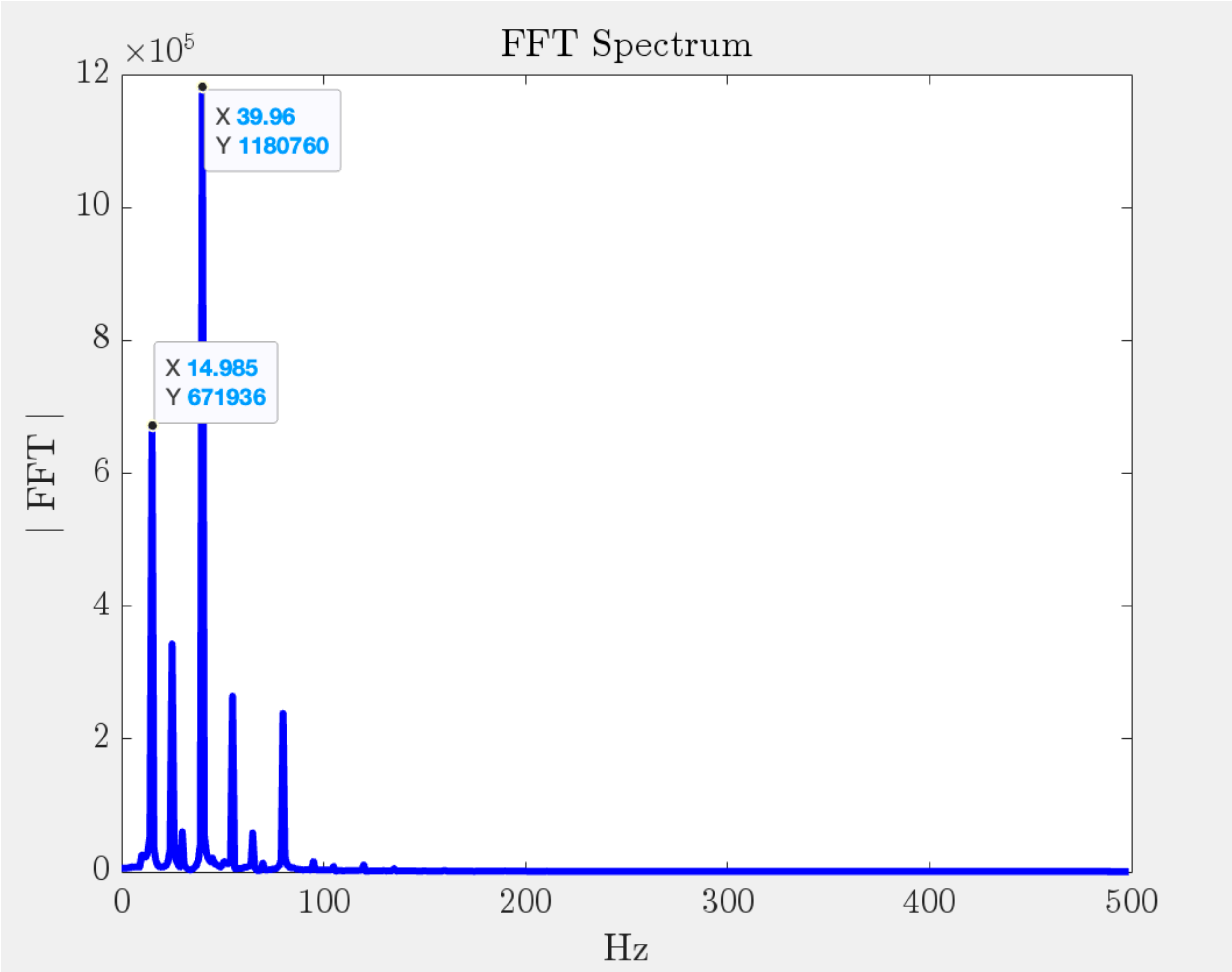
Case : $\dfrac{h_1}{\tau} = 1.36, \dfrac{h_2}{\tau} = 1.58,\ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

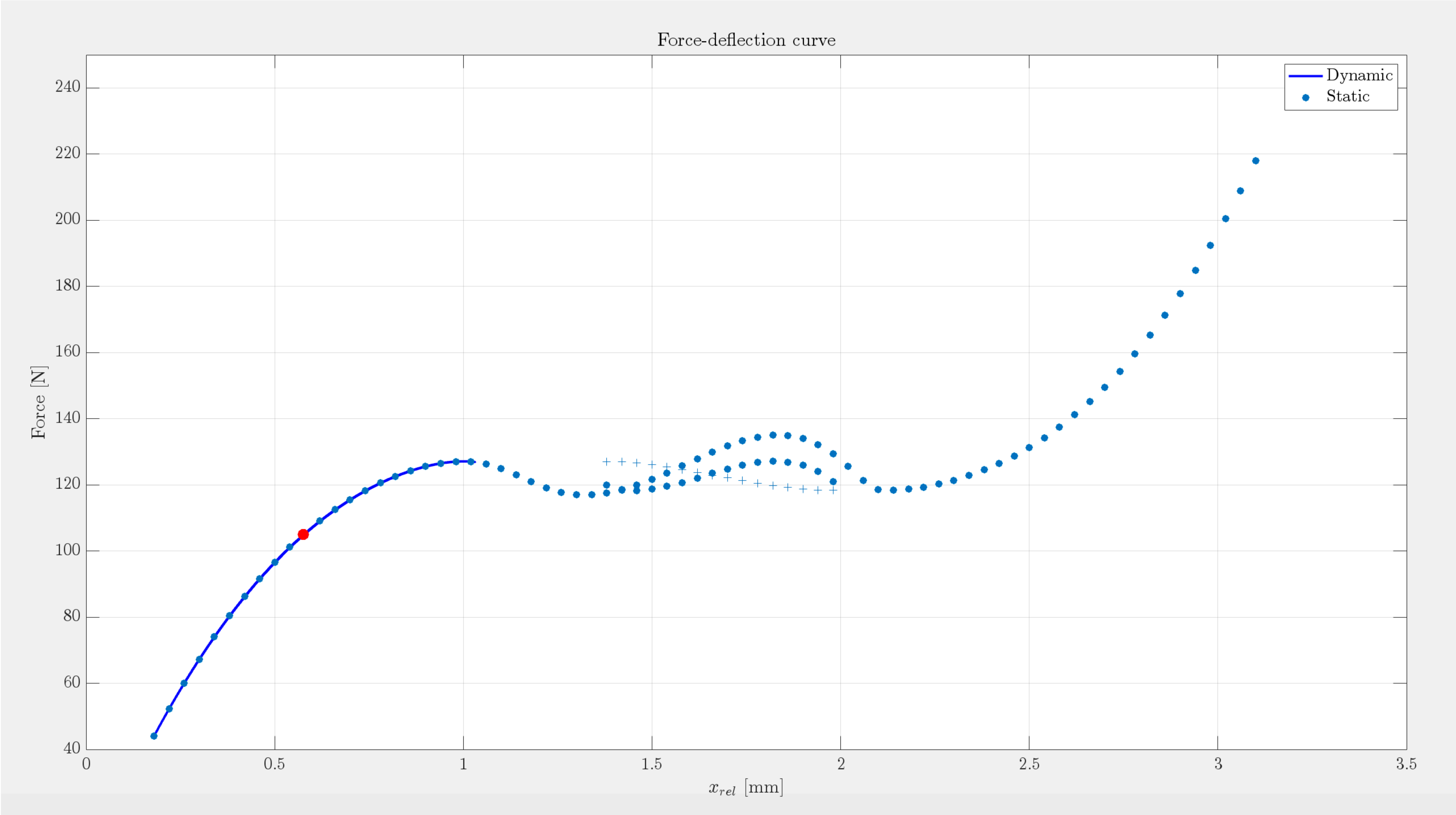
Other examples



Case : $\dfrac{h_1}{\tau} = 1.58, \dfrac{h_2}{\tau} = 1.64,\ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

Other examples





Case : $\dfrac{h_1}{\tau} = 1.58, \dfrac{h_2}{\tau} = 1.64,\ x_{base}(t) = 0.25\sin(80\pi t)$ (in mm)

Scope for Future work

- Study for more combinations of h/τ ratios, especially cases with multiple solutions and are not numerically “nice”.
- Study effects of damping and hysteresis due to snap-through events and other non-linearities