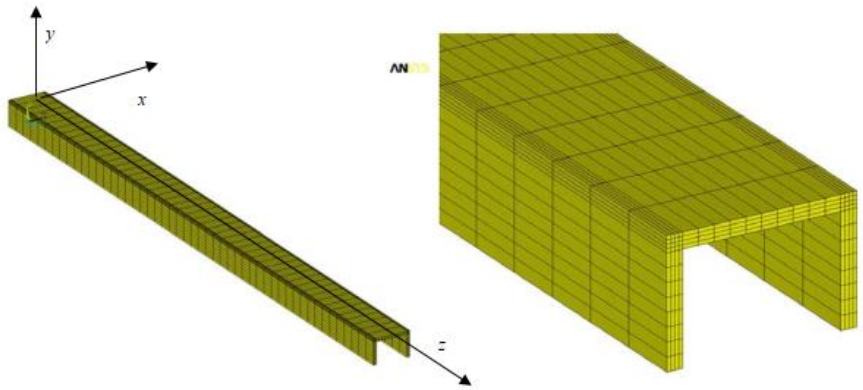
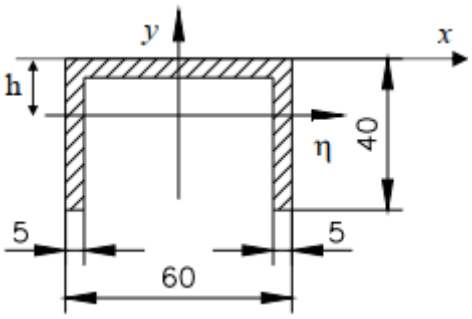
Exercise 2

Transient Analysis = Time/history Analysis

Chanel section 60 x 40 x 1000 mm (5 mm wall thickness) **Cantilever beam from Exercise 2 (Modal Analysis):** Built-in in left end, load F=500N, suddenly applied at the free end for 0.3 s and then removed for 0.2 s.	**Material**: steel E=200 GPa, ni=0.3, ro=8000 kg/m3 Damping of 5%





$J=J_\eta=1.0097\ 10^{-7}m^4$
$A=0.65\cdot10^{-3}m^2$, h=13.27mm

Preliminary estimates:

1. **Damping**: First natural frequency – approx. 230 rad/s (35 Hz)

   Vibration period - approx. 0.03 sec

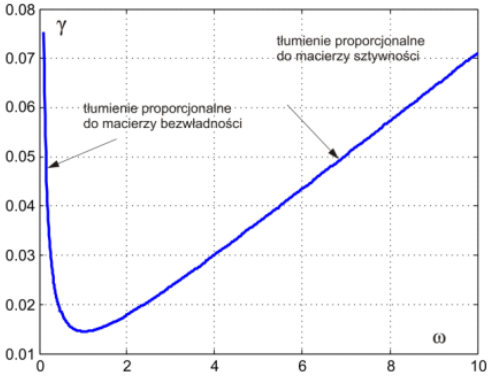
Tłumienie modalne jest skutecznym i wygodnym rozwiązaniem w sytuacji, gdy pomiary (lub założenia) określają udział tłumienia w poszczególnych postaciach własnych. Jest niezwykle korzystne (efektywne) w przypadkach, gdy analiza jest przeprowadzona metodą superpozycji modalnej.

Tłumienie proporcjonalne (Rayleigha) – najpowszechniej stosowanym modelem wyznaczania współczynnika tłumienia w tłumieniu wiskotycznym jest przyjęcie schematu, który postuluje przyjęcie macierzy tłumienia $\boldsymbol{C}$ jako zależnej od macierzy masowej $\boldsymbol{M}$ oraz macierzy sztywności $\boldsymbol{K}$, czyli w postaci:

$$\boldsymbol{C} = \alpha\boldsymbol{M} + \beta\boldsymbol{K} \qquad (2.36)$$

From the Rayleigh damping model, assuming γ=5% (stiffness damping and no mass damping) (i.e. α = 0):

$$\begin{cases} \alpha + \beta\omega_i^2 = 2\gamma_i\omega_i \\ \alpha + \beta\omega_j^2 = 2\gamma_j\omega_j \end{cases}$$



We have : $0 + \beta \cdot 230 = 2 \cdot 0.05$

So for FEM: BETA = 0.000435

ALPHA = 0

2. **Analysis time, division into parts and selection of integration steps**.
   a. The first step is to load 500 N (4 forces of 125 N each).
      Operating time 0.3 sec, i.e. approx. 10 vibration periods.
      We assume 150 steps (i.e. 15 steps per period.)
   b. The second step is to remove the load.
      We count an additional 0.2 sec (up to 0.5 sec). We take 25 steps, which is very THICK... (we have just over 6 periods and only 25 steps).

Steps in ANSYS, cont. Exercise 2:

Solution:

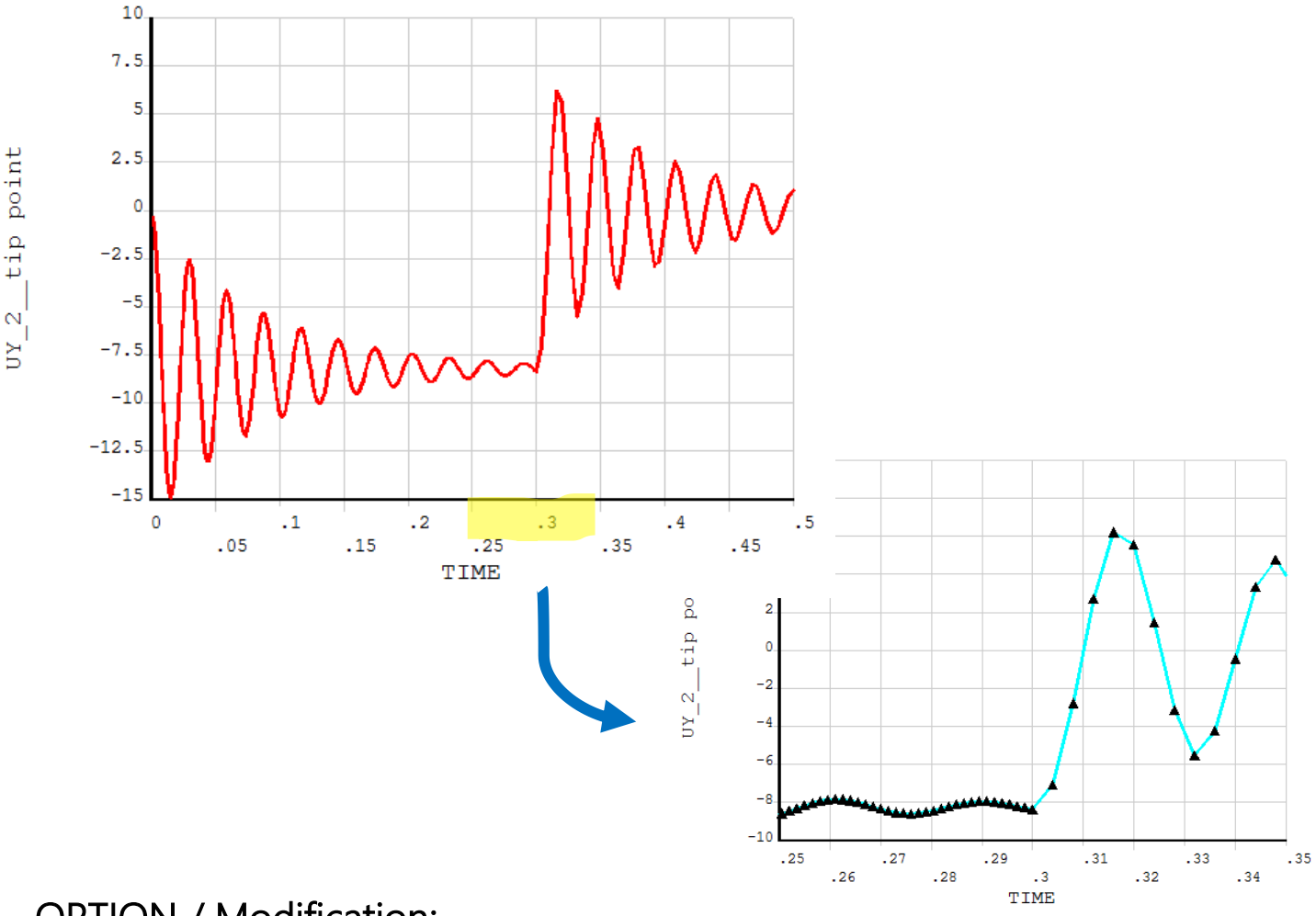
3. Setting the Analysis Type
   a. *New Analysis* – (*Transient* followed by *Full*)
4. The first step of the load – time, steps, damping and load
   a. Control settings (***Analysis Type*** *- Solu Controls*) – up to 0.3 s in 150 steps, constant force loading, total 500N downhill
      i. in the BASIC tab: *Time at end= 0.3 s, Number of substeps = 150*
      ii. in the TRANSIENT *Stepped Loading tab and BETA = 0.000435*
   b. ***Apply*** *Loads-Apply-Structural-Force*
      i. at 4 points at the end (e.g. in Keypoints) FY=-125N
   c. saving the details of this step (**LoadStep Options – Output Controls**) - attention !!
      i. Solu *Printout –Every Substep*
      ii. Write **LoadStep**: *Write LS file* (assign no. 1)
5. The next step of the load – time, steps, damping and load (and in the loop all further steps)
   a. Solu *Controls* – up to 0.5 s in 25 steps, load off.
      i. in the BASIC tab: *Time at end= 0.3 s, Number of substeps = 25*
      ii. in the TRANSIENT b/z *Stepped Loading tab and BETA attenuation = 0.000435*
   b. Define *Loads-DELETE-Structural-Force*
      i. Best – in all KeyPoints
   c. saving the details of this step (**LoadStep Options - Output Controls**) - attention !!
      i. Solu *Printout –Every Substep*
      ii. LoadStep write: *Write LS file* (assign no. 2)
6. Running the calculations of steps 1 and 2
   a. **Solve** – From LS Files (*Starting 1, Ending 2*)

Visualization of results

7. TimeHistory Postprocessing (and further e.g. via icons)
    a. 1st icon (plus) – selection of point and physical component for the chart
    b. 3rd icon – make a chart
    c. 4th icon – listing the results of the selected size
8. Plot *Controls – Style – Graphs*
    a. *Modify Curves, Axis* Range and Type *(Aaxis), Grid*
    b. white background *Plot Controls – Style – Colours -Reverse Video*

Illustration of the results:

1. Beam End Displacement Table (Selected Point)
2. Deformation dumps of several vibration steps (select a moment of time)
3. For a few moments of the DISPLACEMENT map (for the characteristic component of the



OPTION / Modification:

Load modification – damping and comparison with statics

$$\xi = \frac{\delta}{\sqrt{(2\pi)^2 + \delta^2}} \overset{dla\ \delta^2 \to 0}{\cong} \frac{\delta}{2\pi}$$

gdzie: $\delta = \ln(A_i / A_{i+1})$ - logarytmiczny dekrement tłumienia.