

## General Information

The software “vibration absorber” simulates a damped spring-mass system with a main mass and a smaller mass, which is operating as a vibration absorber. Two springs are mounted horizontally, whereby the system is non-linear and they reinforce the redemption.

It is possible to run several simulations with this programme, where the user can adjust the mass of the system or the spring stiffness for example.

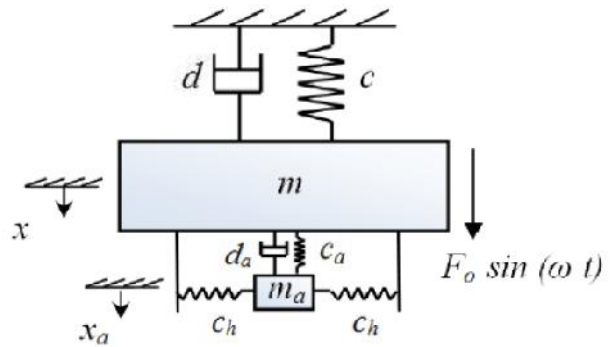
There are also several calculation methods to choose from and they can be compared as well.

The user also can compare linear systems with non-linear ones. For instance, the effect of the horizontally springs can be investigated.

If the calculation is completed, the results are shown in five different charts.

These five charts are the deflection, velocity of the mass, deflection over the frequency ration, phase space and the so called Poincaré-diagram.

This software was fully programmed with MS Visual Studio in C#.



## User manual

### Main menu

The software is structured in several windows. Each window has its own function.

After starting the program, the main menu shows up, from where the user can continue with the simulation.

By choosing **Calculation → New** the interface with all parameters for the calculation appears. If there is an already saved calculation, it can be loaded with a click on **Calculation → Load**.

The user can also load a whole simulation with a click on **Load Project**. Then the visualization window pops up immediately without the parameter window (for that a calculation, respectively a simulation must be saved as a project before).

The small object in the middle of the main menu is a “shortcut” which allows the user to get to the calculation immediately.

To close the software, click on **Close Program**.

## Parameter-interface

In the parameter window the following coefficients can be adjusted:

- Mass  $m_1$  and  $m_2$  in kg
- Spring stiffness  $c_1$ ,  $c_2$  and  $c_{nl}$  in N/m
- Damping coefficient  $d_1$  and  $d_2$  in N s/m
- Separate excitation  $F$  in N
- Frequency of separate excitation in 1/s
- Increments  $h$
- Calculation time  $t$  in s
- Prestressing force of the non-linear spring  $F_V$  in N
- Length of the non-linear spring  $l_F$  in m
- Initial conditions of the deflection of the masses  $s_1$  and  $s_2$  in m
- Initial conditions of the velocity of the masses  $v_1$  and  $v_2$  in m/s

After the adaption of all values, at least one of the following calculation methods must be chosen:

- Euler
- Runge-Kutta 4<sup>th</sup> degree
- Heun (Predictor-Corrector-algorithm)

It is also possible to choose between linear and non-linear, whereby there are six possible choices.

If several methods are compared, the user has to make sure, that the combinations are useful.

For better understanding a few examples are given:

- A combination of two or three calculation methods of the same type (linear or non-linear) is useful  
(e.g. Euler linear & Runge-Kutta linear)
- A combination of the same method, but here the linear and non-linear one are compared to each other → useful  
(e.g. Euler linear & Euler non-linear)
- It is not useful to compare one/more linear method(s) with another non-linear one(s), or vice versa  
(e.g. Euler linear & Runge-Kutta non-linear)

## Parameter-interface (Continuation)

If all required choices are made, the button **Calculate** changes its colour to green. With a click on that button the calculation is accomplished and the visualization window occurs.

To save a new file with the previous settings click on **File → Save as**. The command **File → Save as** only works after a file was already saved or loaded.

With a click on **File → Load** the user can reload an already saved file.

With a click on **File → Close** the user gets to the main menu after a save request. The same operation is accomplished with **Stop**, just without the save request.

When the parameter window is opened initial values are coloured in grey. After some changes are made the user can reset the settings with **Calculation → Reset**.

### Caution:

The calculation time of the simulation depends on the chosen settings. The more calculation methods are chosen, the longer it takes to calculate. Therefore, it is recommended to choose a maximum of four calculation methods, because this software is not optimized for that case.

The same issue can occur at very small increments.

## Visualization

The visualization displays all calculated values in several charts. These charts are the deflection, velocity of the mass, deflection over the frequency ratio, phase space and the so called Poincaré-diagram.

Here it is also possible to save individual charts. (but only one chart at once) The chart is saved as an image file with a click on **File → Save**.

With **File → Close** or **To Main Menu** the user gets back to the main menu.

It is possible to change the size of each chart, according to its purpose. To adapt it the user just has to move the cursor between two charts until the cursor changes.

With a right-click on any chart it can be faded. To show them again click on **Visual → Reset Charts**.

The user can select several charts of all calculation methods. With a click on the button **Selection** a new window opens.

The software allows the user to simulate a maximum of two calculation methods simultaneously. In that case another button **Simulation** occurs green and the simulation of the calculated and selected system(s) is enabled. If more than two methods are selected, the button is coloured in red and the simulation is deactivated.

As mentioned before, the number of methods can be adapted in the selection window, to enable the simulation again.

## Selection

As mentioned before, the user has access to the selection window from the visualization. It is possible to enable or disable several/all charts of a calculation method. Therefore, every method has its own **Check Boxes**.

With a click on **Select All** it is possible to make a multiple choice. (faster)

If a method is selected which was not calculated before, it takes a certain time to calculate.

The software is designed to disable all charts, which are not relevant. For example, if the user only selects the deflections of one method, only that chart is visible.

If all charts are disabled a fault message appears and the simulation is not possible as well.

## Simulation

In the simulation the calculated system is displayed graphically and dynamically. There are either one or two systems which can be selected and simulated simultaneously.

After the simulation window opens the button **Start Simulation** appears in the middle of the screen. With a click on it the dynamic simulation of the spring-mass system starts.

If the user only selects a single calculation method, the display is distinguished from a comparison of two methods.

In case of a single simulation the left half of the screen shows the vibration absorber. The right-hand side shows two diagrams including the phase space and the deflections of the system.

In a double simulation the screen is halved as well, but instead of the phase space only the systems itself and the deflections are shown.

The user has the possibility to change all parameters of the system for the calculation in the simulation. With a click on the button **Stop** another parameter window opens at the edge. Meanwhile the name of the button changes to **Start** and with a click on it the simulation restarts with the adapted values.

With a vertical **Trackbar** on the right-hand side the user is able to adapt the frequency of the system within the limits. Then the system reacts to the selected frequency.