

EcosimPro

Modelling and Simulation Software



MECHANICAL LIBRARY

The MECHANICAL 1D object-oriented modelling library contains a set of translational and rotational components that facilitate the easy implementation of kinematic and dynamic studies of each component in the system.

EcosimPro

EcosimPro is a powerful **modelling** and **simulation** tool with a simple interface that makes the design of **multidisciplinary** dynamic systems easy and intuitive using graphic diagrams.

For users with specific needs, EcosimPro provides an object-oriented non-causal approach towards creating reusable component libraries and is based on very powerful symbolic and numerical methods capable of processing **complex systems** represented by differential-algebraic equations (DAE) or ordinary-differential equations (ODE) and discrete events. However, low-level problems such as programming calls with numerical solvers, equation handling, etc. are solved automatically or using simple wizards.

Features

MECHANICAL is a standard library which is supplied with EcosimPro and contains components to model **1-dimensional** translational and rotational mechanical systems. The library has been designed to run **fast stiffness simulations**, even with coupled friction elements. On the other hand, because directional forces are not contemplated, the force of gravity on masses is not taken into account whereas **inertial forces** are.

Using **drag & drop** methodology, the user can quickly create a diagram of the mechanical system to be analysed, the representation of which is very similar to the physical system.

Thanks to EcosimPro's features, the MECHANICAL library is very easy to **configure** and **extend**, adding any components and characteristics as needed. This can be done graphically through a simple, user friendly interface, or through EcosimPro's **object-oriented language** which makes it possible to re-use existing codes.

Applying the object-oriented methodology, a group of components can be encapsulated into a single subsystem

used like a **black box**, with a defined number of inputs and outputs. This enables **modular** design of the overall system and makes it possible to share tasks among different specialised **users** or merely simplify the system.

One of the library's biggest advantages is the possibility of its use in the multidisciplinary facet of EcosimPro. This means that we can design, for example, the power stage of a motor coupled to a transmission system and, at the same time, study the dynamic response of each of its elements and the effect that mechanical changes (for example, changing gear) have on the electronic components. In this way we obtain an **overall study** of the system, minimising possible problems during commissioning.

The components

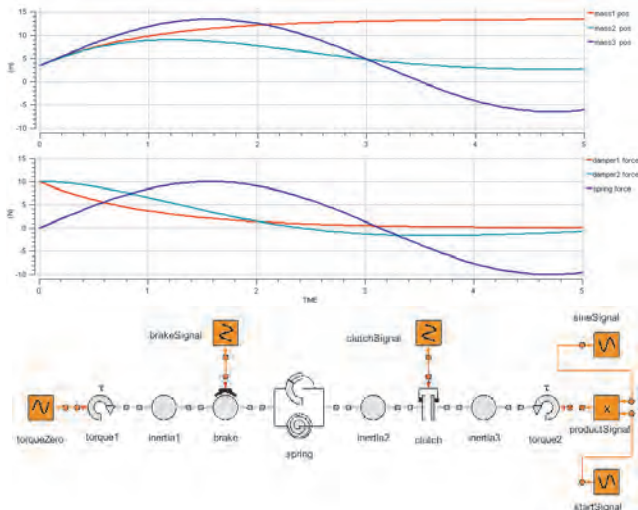
The library is composed of two types of components, namely:

- **Rotational:** Components to model 1-dimensional, rotational mechanical systems
- **Translational:** Components to model 1-dimensional, translational mechanical systems

In summary, different component groups will be established and included in the MECHANICAL library with several representative examples:

- **Masses and inertia:** These elements implement the second Newton law. Sliding mass, end stop mass, inertia and end stop inertia
- **Force and torque generators:** They calculate force or torque from the position or the velocity in their ports. Coulomb friction, dampers and springs
- **Actuators:** They provide force, torque, acceleration, position and angle, depending on an external input





signal (user defined law). Force, position, torque, acceleration and angle generators

- **Sensors:** These components generate output CONTROL signals with the acceleration, velocity, position and force signals. Acceleration, velocity, position, angle, force and torque measurement
- **Special rotational elements:** Levers, pistons, clutch, brake and efficiency

Example

A translational example

The following example is a very simple demonstration of the damper and spring elements.

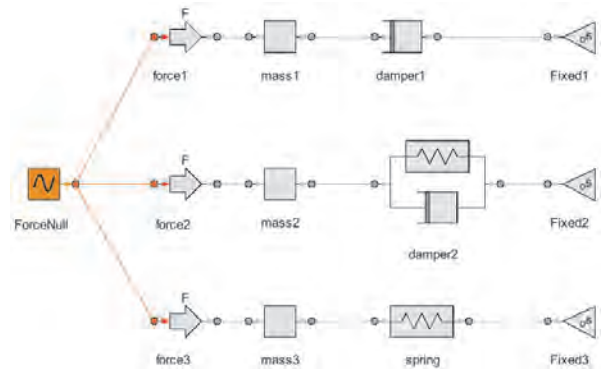
It consists of three equal masses that start from an initial position of 3 metres with respect to the reference position. In the three cases we apply a nil force (this is a requirement of the model to close the system of equations) and they therefore act freely starting from a position with respect to the reference position of 3.5 m and at an initial velocity of 10 m/s.

In the case of “mass1”, the damper causes it to lose speed regardless of its position and it quickly stabilises; “mass3”, the spring, maintains a harmonic movement with respect to its initial position; “mass2”, the spring combined with a damper, is an intermediate case in which force is gradually lost with a tendency to restore the initial position.

A rotational example

This example demonstrates how a drive train structure works. The drive train consists of 3 inertias — a brake, a clutch and a spring with damper.

Up until instant 0.5 seconds, the system is excited with a



sinoidal moment in “inertia3”. At the same time that this input is cancelled, the brake changes from being inactive to being active. The clutch will at all times remain active, although its friction value will be relatively small which will permit it to slip easily.

We can see in the graph that “inertia2”, of small value, almost always follows “inertia3” with some slight slippage which is largely absorbed by the spring-damper.

Once activated, the brake slips slightly for 0.16 seconds until it finally engages. Given that the new configuration makes the connection of inertia2 with “inertia1” stiffer than with “inertia3”, the clutch starts to continuously slip until the direction of rotation of “inertia3” starts to change, enabling the damper to engage and release the energy accumulated in the spring.

With several simulations it would not be difficult to calculate, for example, the minimum friction so that the clutch always remains engaged (in this case, the maximum force withstood by the clutch before slipping is 1392 N).

