

DYMOLA – Flexible Bodies Library

Overview:

- Efficient object-oriented mathematical modeling of flexible structures

Key Features:

- Beam model based on analytic solution of the spatial eigenvalue problem of an Euler-Bernoulli beam equation
- Supports bending in two planes, torsion and lengthening deformation
- Accounts for geometric stiffening and buckling effects, such as the weak bending behavior of a slender beam under the influence of an axial thrust force
- Supports input of all necessary geometrical and physical properties of a straight and homogeneous beam
- General and specific types of cross sections definition
- Animation to visualize deformation

Benefits:

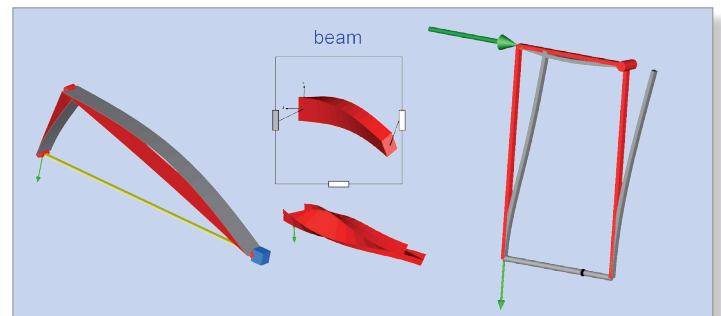
- Creation of mechanical systems mixing rigid and flexible beam structures
- Compatible with other Modelica libraries such as MultiBody and VehicleDynamics
- High simulation performance

> System simulations with flexible bodies

The Flexible Bodies Library enables and supports the object-oriented and mathematical efficient modeling of flexible bodies as components of multi-body and arbitrary physical systems.

> Floating frame of reference approach

The motion of the flexible body is defined by a superposition of a large (in general), non-linear motion of a reference frame with small elastic deformations. This approach leads to a specific, advantageous structure of the equations of motion, for which the necessary data are stored using the open Standard Input Data (SID) format.



Large motion of beam-like structure

> Beam-like structures

The Flexible Bodies Library provides a specific Modelica® class, the beam model.

If a beam object is instantiated, a dialogue menu supports the definition of the geometrical and physical properties of a straight, homogenous and isotropic beam.

The beam model takes bending in two planes, lengthening and torsional deflections into account. The deformations are discretized by eigenmodes that may be selected according to the actual needs. The eigenforms and eigenfrequencies respectively are to be specified by their ordinal numbers. These features give the experienced modeller the possibility to reduce the degrees of freedom and neglect those eigenmodes that do not contribute to the modeling problem. The damping coefficient may be assigned to each eigenfrequency separately.

Typical Application

> Example – Helicopter Rotor

The model Helicopter Rotor mainly consists of a reeonom driven, cylindrical rotor base, two joints and one blade. The rotor base rotates around its cylindrical axis that coincides with the global z-axis, while the lag joint allows for a rotation around a local z-axis at the outer radius of the rotor base. The flap joint defines an angular motion around the local y-axis at the circumference of the rotor base.

In its initial state the rotor base does not move and the flap stop (a bump stop) applies the torque to counterbalance the gravity of the blade. A linear spring-damper element actuates according to the state of the lag joint and transmits the drive torque to the blade.

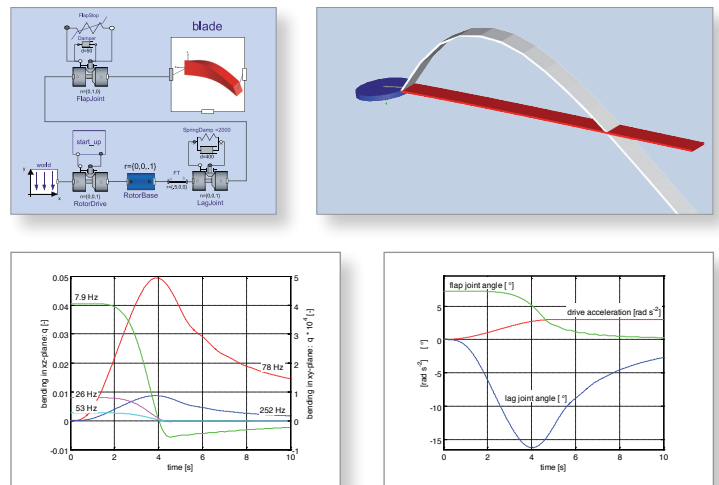
The 6-m-long blade is modeled as a flexible beam with 7 bending modes in its xz-plane and 2 bending modes in its xy-plane, so that a frequency range up to 270 Hz is covered.

The 3D-view of the model depicts its initial configuration. The grey animation is a scaled version of the red animation and exaggerates the deformations of the blade. The first result plot shows the applied, smooth rotor drive acceleration of the simulated start-up scenario.

The flap joint angle tends against zero with increasing rotor rotation so that the blade moves towards its vertical alignment.

The second result plot presents the deformation behaviour for 2 bending modes in xy-plane (with 78 Hz and 252 Hz eigenfrequency) and 3 bending modes in xz-plane (related to 7.9 Hz, 26 Hz and 53 Hz eigenfrequency). Generally, all modal amplitudes decrease with increasing angular velocity and clarify its stabilising influence. Note that the reproduction of the stabilising effect relies on the consideration of geometric stiffness terms.

The Flexible Bodies Library is designed, implemented, and maintained by DLR, the German Aerospace Center, Institute of Robotics and Mechatronics in Oberpfaffenhofen, a Dassault Systèmes technology partner.



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