HyQ2Max Leg SimMechanics Model

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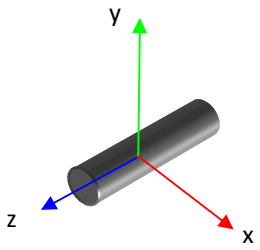
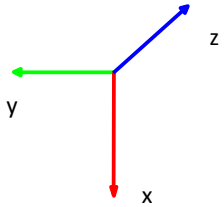
The World reference frame (*XYZ*) in SimMechanics is a fixed right handed coordinate system so that the positive x-axis points to the right, the positive y-axis points upwards and the positive z-axis points out of the screen completing a right handed coordinate system. The selection of local body reference frames is the same as for HyQ and is described in the document HyQV1LegV2_StandardDefinitions_v2 by carrying out an Euler ZXZ rotation, [-90 180 0] degrees of the World reference frame.



SimMechancis
World Coordinate

Euler ZXZ rotation
[-90 180 0] degrees

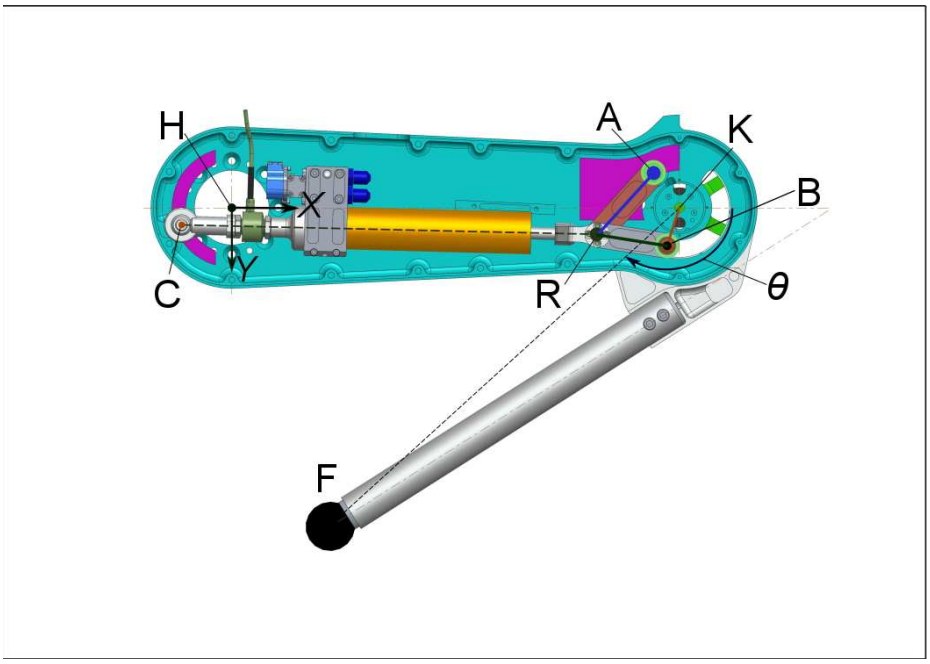


Upper and Lower Legs
Local Body Coordinates

Mass, inertia about the centre of mass and the centre of mass coordinates for upper and lower legs are obtained from CAD data. The base of the upper leg is selected as the origin of the World coordinate system and is where the hip joint is located. The remaining upper leg parameter values are translated from the base location and are given in body coordinates. The base for the lower leg is selected as the origin for the lower leg relative to the upper leg. The remaining lower parameter values are translated from the base and given in local coordinates. The SimMechanics leg model normal configuration is a fully extended leg. Note that this violates the angle range for the knee and a hard stop is included to ensure that hip and knee angles are within the admissible regions. A small amount of damping is added to each joint so that leg dynamics are stable.

The hip joint is actuated by a hydraulic motor while the knee joint is actuated by a “lever” mechanism with a double acting piston/ piston/cylinder. The hip hydraulic motor parameters include the motor displacement constant (m^3/rad), the shaft stroke, the shaft initial position and a hard stop. The knee “lever” mechanism is connected to the upper leg as described later in this document. The cylinder piston, rod and oil masess are included in the SimMechanics model of the lever mechanism. These masses can be set to small values if they are included in the hydraulic dynamics model. The SimMechanics model for the knee joint includes a one degree of freedom prismatic to represent the double acting piston/cylinder. The normal configuration is initially specified for the fully extended leg but varies with the leg motion. The double acting cylinder parameters include the area for each side of the piston, the piston stroke and the inital position of the piston. This provides the limits for the hard stops in the cylinder.The oil volume dynamics are not accounted in the SimMechanics model but can be incorporated in a model with the pressure dymanics of the cylinder or hydraulic motor chambers and servovalve. The prismatic joint sensor provides piston position and velocity which are needed to model the hydraulic dynamics. The cylinder or hydraulic motor do not include leakage nor friction but a model with viscous friction as well as nonlinear friction can be added in future refinements. Hard stops are modelled as contacts with spring-dampers having sufficiently high values.

Lever Mechanism for the knee Joint (hind legs LH/RH)



H denotes the hip joint and is the origin for the local coordinate frame XY
C is the fixed position where the back of the cylinder is attached to the upper leg
A is the fixed position where the link RA is attached to the upper leg
R is the moving positon where the other end of the cylinder is attached
B is the fixed position where the RB link is attached to the lower leg
K denotes the position of the knee joint relative to H
F denotes the tip of the foot ball realtive to the knee joint location K
ψ is a constant angle between the lines KB and KF
θ denotes the knee joint angle measured from the line HK
CR is the cylinder length which varies a s a function of the knee joint angle θ

For the current design
The location of C is x = -41 mm, y = 5 mm (x = -41 mm, y = - 5 mm for LF/RF legs)
The location of K is x = 360 mm, y = 0
The location of A is x = 320 mm, y = -23 mm (x = 320 mm, y = 23 mm for LF/RF legs)
RA= 56 mm
RB= 56 mm
BK= 34 mm
ψ = 39.5 degrees (-39.5 for LF/RF legs)
θ varies from 2 to 168 degrees (-2 to -168 degrees for LF/RF legs)
In SimMechanics the link CR mass and inertia are set to 0.09 kg and Ie-4 kgm^2 while for the links AR and BR the mass is sett 0.01 kg and the inertia Ie-3 kgm^2. These parameters can be changed to values for the actual links. For CR the mass corresponds to the piston, rod and oil volume as in HyQ.