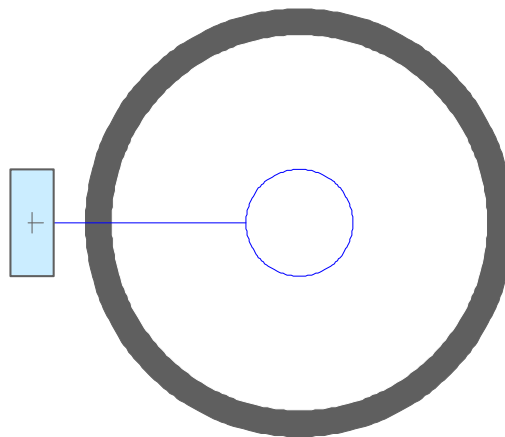


# Virtual Physics

26.11.2013

## Exercise 7: 2D-Mechanics: Ideal rolling wheel

**Task A: Develop a component for an ideal wheel joint.**



name

Model a wheel joint (i.e. a wheel without mass and inertia) that exhibits an ideal rolling on the x-axis (or on the xz-plane in the 3D Visualization). Although, the wheel is regarded as joint-element, it has only one connector since the other connection point is implicitly represented by the x-axis.

Such an ideal rolling wheel imposes one holomic constraint for the position on the y-axis and one non-holonomic constraint in order to enforce ideal rolling.

$$y = R$$

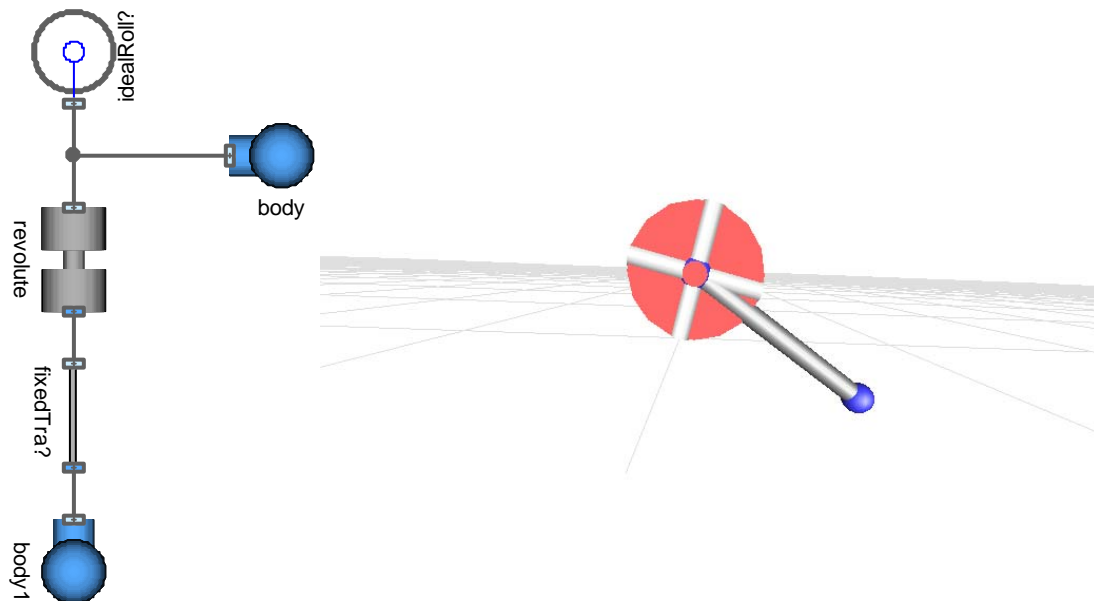
$$R \cdot \omega = v_x$$

The wheel joint defines one parameter and that is the radius of the wheel. Since this rolling is restricted to a single dimension, the non-holonomic constraint may be elevated to a holonomic constraint.

Provide also a suitable 3D animation for your component.

### Task B: Test your component

You can test your ideal wheel joint by using it as a replacement for the prismatic joint in the crane crap.



### Task C (optional): Model a rigid wheel with dry friction

Instead of imposing a non-holonomic constraint equation, one may apply the law of dry friction. Implement a second wheel joint with a dry friction model and use it to remodel the ball with counter-spin of Lecture 5a. *Beware: the normal force is not a parameter of the model anymore. It results out of the holonomic constraint. Can the normal force become negative?*

### Task D: Apply Pantelides Algorithm (taken from Exam WS 2010/2011)

Transform the following system of differential-algebraic system into state-space form.

$$\dot{x} = 5 * z * b$$

$$\dot{y} = a$$

$$2 * \dot{z} = b$$

$$b = y * x$$

$$y = 1 - x$$

$$a = c - d$$

$$d/2 = b$$

Causalize each equation and transform the set of equations into a sequence of assignments. You may differentiate equations if necessary.