

# Virtual Physics

21.10.2014

## **Exercise 4: Implementing your own Hydraulics Library**

In the last exercise, we derived the equations of a few basic hydraulic components. You may want to implement them in form of your own Modelica library.

### **Task A: Library structure**

Think about an appropriate library structure. Do not over-elaborate! Make it simple.

### **Task B: Model the interfaces and base-models**

Model the connector and maybe a partial base component.

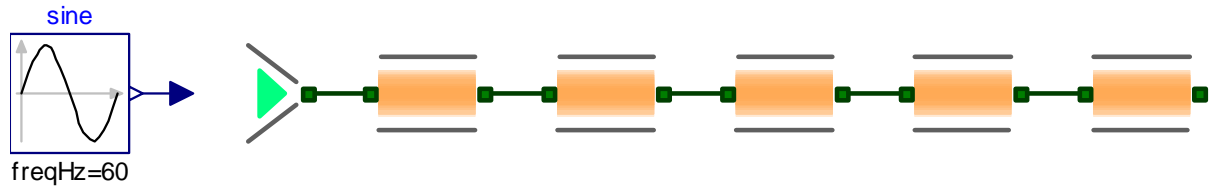
### **Task C: Model the components**

Model four components:

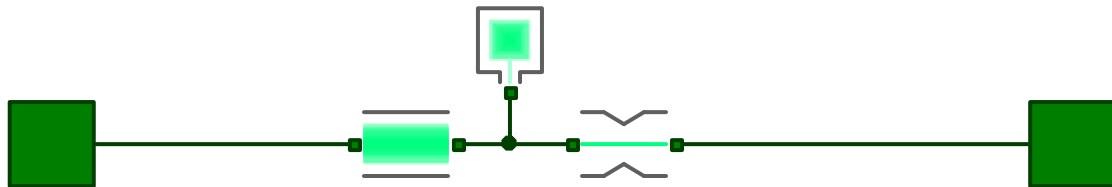
- A pipe friction (laminar flow)
- A pipe mass
- A compressible volume
- A pressure source with input signal.

### Task D: Set-up an experiment: The speed of sound.

Now we model the propagation of a sound-wave in an air tube. The tube has the length of 1m and is discretized into 5 segments of 20 cm.



Each segment can be modeled by a combination of induction (mass), compression and friction.



The pipe has a cross section of 10cm x 10 cm. For air we assume a pressure of 1 bar =  $1e5$  Pa. This is also the reciprocal of the compressibility  $\kappa = 1e-5$  Pa. The density at this pressure and 20°C is  $1.29 \text{ kg/m}^3$ . The friction drop per 20cm shall be modeled by  $k = 5000 \text{ Pa s/m}^3$

The input pressure shall be a sinus-curve with amplitude of 100 Pa (approx. 134dB = Motörhead) and a frequency of 60Hz. The rear end of the pipe is sealed. This means no volume is flowing out (Hint: simply leave the connector unconnected).

Simulate for 0.05 seconds and examine the propagation of the wave. Can you measure the speed of sound? Up to what frequencies can you use this model? What would you have to do to simulate the same pipe but with a frequency of 5kHz?