

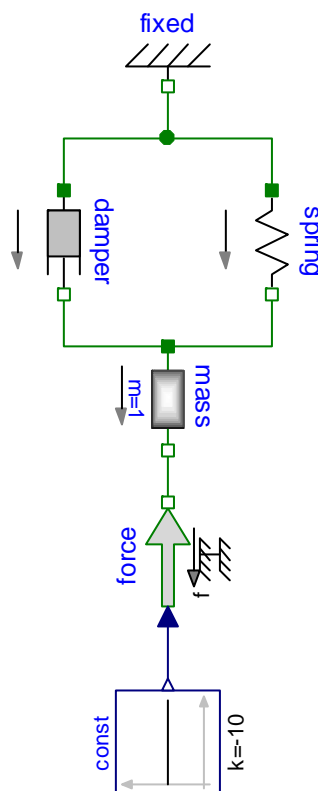
# Virtual Physics

22.10.2013

## Exercise 3: Mechanics, Electrics, Hydraulics

### Task A: Model the equivalent electric circuit.

In the lecture, you have learned that both, mechanical system and electrical systems can be described in the same way by modeling the corresponding energy flows. Let us consider the following mechanical system:



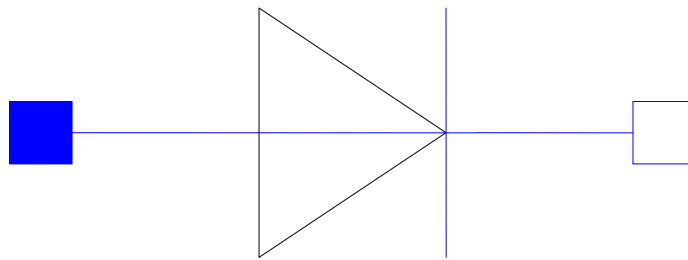
It represents a mass attached to a spring-damper pulled by a force. The following parameters are applied: mass = 1kg, spring coefficient = 10N/m, damping coefficient = 2N/m, force = -10N, initial position of the mass = 0m.

The corresponding modeling file SimpleSpringDamperTask.mo can be downloaded from the website. Simulate the system for 10s and plot the velocity of the mass.

Using the analogies presented in the lecture, now model an equivalent electric circuit using the correspondent Modelica library: Modelica.Electrical.Analog.

The electric circuit shall lead to exactly the same simulation result. Simplify the circuit if possible.

### Task B: An ideal diode.



Draw the characteristic curve of an ideal diode: Flow(current) over potential difference (voltage). Think about a device that would form an analogon in the mechanical domain. What is the energetic behavior of these devices?

### Task C: Modeling Hydraulic Components


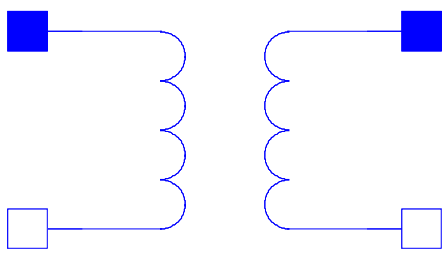
So far, we have not concerned ourselves with the modeling of hydraulic system. However, since these systems are subject to same laws of thermodynamics, we can quickly model their basic components.

As in electrical or mechanical systems, the Interface of hydraulic components is described by a pair of potential and flow variables. The flow is described by a flow of volume  $v$  [ $\text{m}^3/\text{s}$ ]. Its counterpart, the potential variable, is the pressure  $p$  [ $\text{N}/\text{m}^2$ ]. Again the product of this pair represents a flow of energy [ $\text{Nm}/\text{s} = \text{J}/\text{s}$ ].

Below you find a table with the basic electrical components on the left. Your task is to fill out the table on the right by modeling the correspondent hydraulic counterparts.

Draw a suitable icon and write down the model equations in hydraulic terms. Describe in words how energy is stored, transformed or dissipated. Compute the physical unit of the linear coefficients and provide physical explanation.

Electrics	Hydraulics
<div data-bbox="258 380 713 508" data-label="Diagram"> </div> <p data-bbox="236 544 740 577">Resistor with Resistance <math>R</math> [Ohm = V/A]</p> $u = R \cdot i$ <p data-bbox="215 687 761 763">A resistor dissipates electrical energy into heat.</p>	
<div data-bbox="252 1220 721 1344" data-label="Diagram"> </div> <p data-bbox="242 1453 730 1487">Capacitor with capacitance <math>C</math> [F = C/V]</p> $du/dt \cdot C = i$ <p data-bbox="201 1597 772 1673">A capacitor stores energy in an electric field built up by the charge of the capacitor</p>	

Electrics	Hydraulics
 <p data-bbox="271 560 702 616">Coil with inductance <math>L[H = Vs^2/C]</math></p> $di/dt \cdot L = u$ <p data-bbox="215 705 758 750">A coil stores energy in the magnetic field.</p>	
 <p data-bbox="470 1388 518 1444"><b>M</b></p> <p data-bbox="239 1478 734 1523">Electrical transformer with gain <math>M [1]</math></p> $u_2 = M \cdot u_1$ $M \cdot i_2 = i_1$ <p data-bbox="199 1691 774 1870">It transformrs energy and is non-dissipative. The transformation is done by a magnetic field in between. Effects due to resistance and inductivity are neglected.</p>	