5ELEN018W - Tutorial 3 Exercises: Simulink

Familiarisation with Simulink

In this exercise, we will build from scratch a Simulink model of the mass-spring damper (surgical robot arm) system. Refer to the relevant slides of the last lecture.

The system is described by the following second order differential equation:

$$m\ddot{x} + b\dot{x} + kx = f \tag{1}$$

and the system is shown in Figure 1.

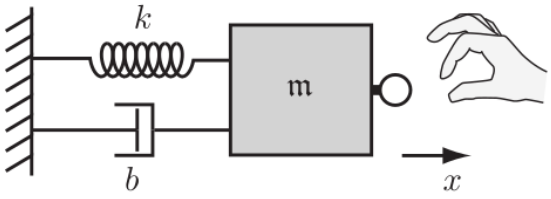


Figure 1: The mass-spring damper system.

1. Rearrange equation (1) so that only the term $\ddot{x}$ is in the left hand side of the equation.
2. Construct a Simulink model of the system as shown in Figure 2 with the following values of parameterd $b = 10$, $k = 400$, $m = 20$.
3. Change the parameters b, k and m and see what happens in the oscilloscope.

Build your own Simulink Model

Build a Simulink model for the following continuous dynamic system:

$$\frac{dT}{dt} = -r \cdot (T - T_{env}) \tag{2}$$

which describes the Newton's Law of Cooling:

"The rate of heat loss of a body is directly proportional to the difference in the temperatures between the body and its environment.".

`https://en.wikipedia.org/wiki/Newton_law_of_cooling`

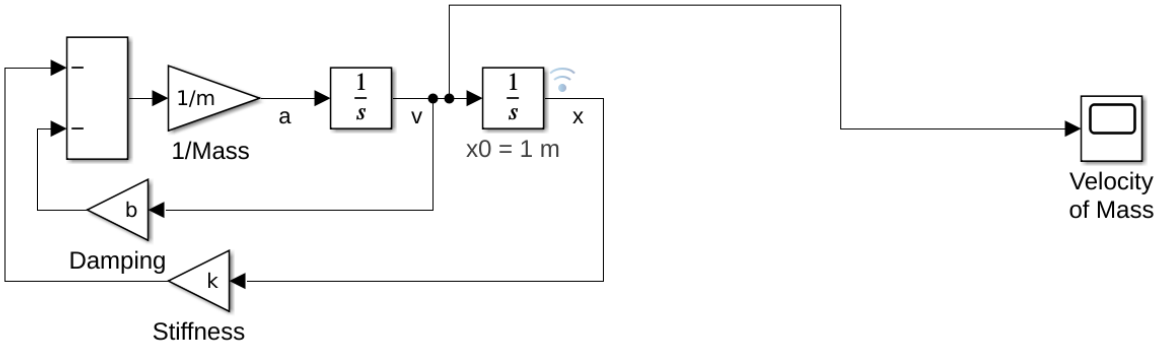


Figure 2: The Simulink model of the mass-spring damper.

The body will reach the environment's temperature and remain there. How quickly this happens depends on the coefficient of heat transfer r. The larger its value, the faster the body will approach the environment's temperature.

Try the following values: $r = 2$ and $T_{env} = 30$, but feel free to change them afterwards to confirm your intuitions.

Set the initial condition of the differential equation to $T_0 = 300$, by setting the initial condition in the Integrator block to this value (double click on the Integrator to see and then change this value).

Observe with the oscilloscope (the `Scope` block in Simulink) how quickly the T value reaches the environment temperature T_{env}. Add a second input to the oscilloscope, the rate of temperature change $\dot{T}$.

Discrete Dynamic Systems

Discrete dynamic systems are described with difference equations which relate to time delays in signal values.

Here we will see how to build a Simulink model of the following discrete system simulating the distance travelled with speed v starting at position x_0:

$$x(t) = x(t-1) + v * \Delta t \tag{3}$$

The term $x(t-1)$ can be created by using a unit-delay Simulink block whose input is signal $x(t)$ and the output is the delayed signal $x(t-1)$. This is similar to the integration block for continuous systems (differential equations) but for difference equations where time steps are discrete.

The end result is shown in Figure 3, but we will see how this is derived in the tutorial.

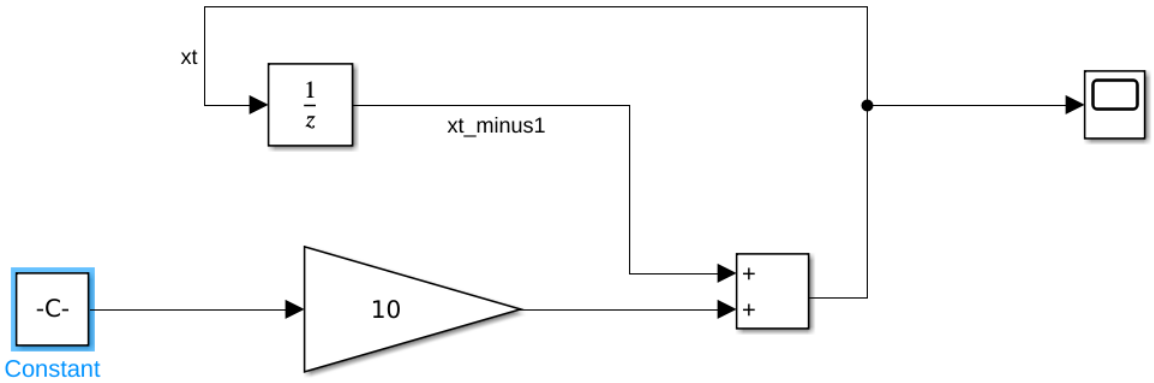


Figure 3: Distance travelled with constant speed v. An example of a difference equation.

A Further Tutorial on Simulink

To learn more about Simulink follow the tutorial at the following URL:

`https://matlabacademy.mathworks.com/details/simulink-onramp/simulink`.

This takes about 3 hours to complete but you can suspend it and continue from where you stopped later on.