# 5ELEN018W - Tutorial 4 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.

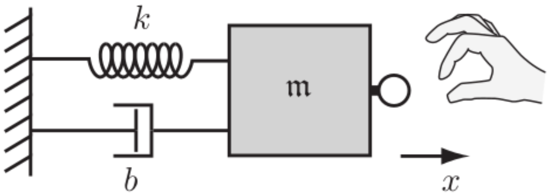


Figure 1: The mass-spring damper system.

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

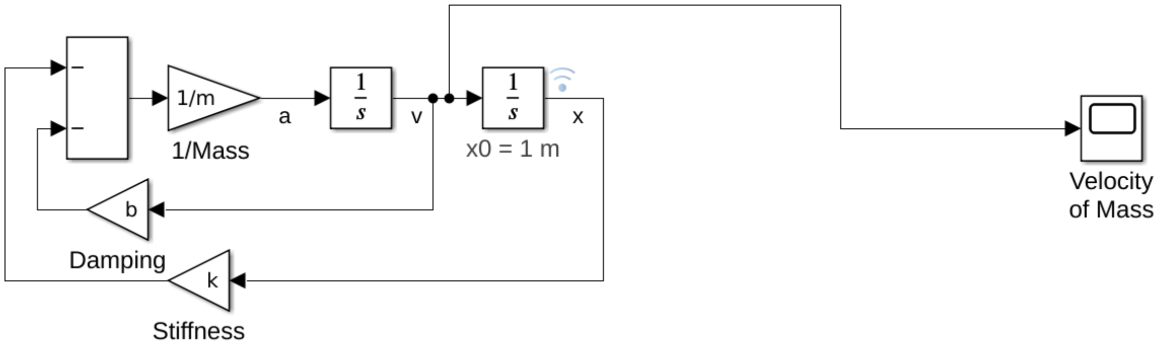


Figure 2: The Simulink model of the mass-spring damper.

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

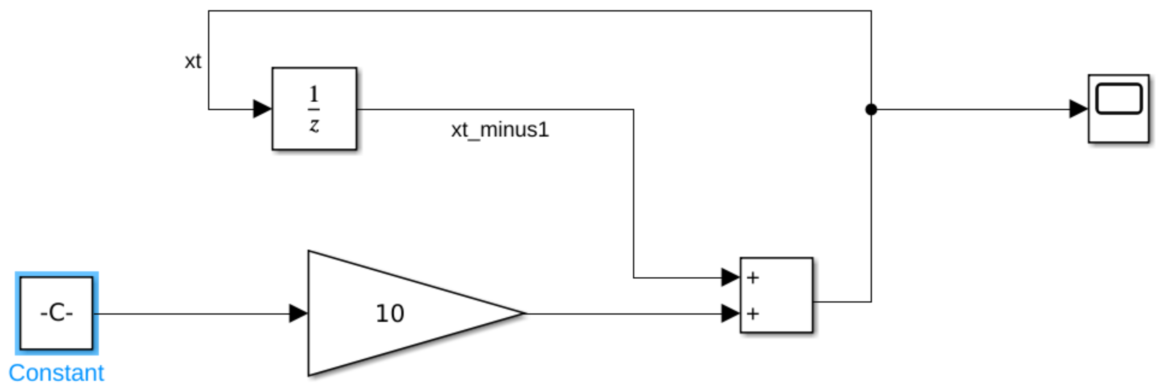


Figure 3: Distance travelled with constant speed $v$. An example of a difference equation.