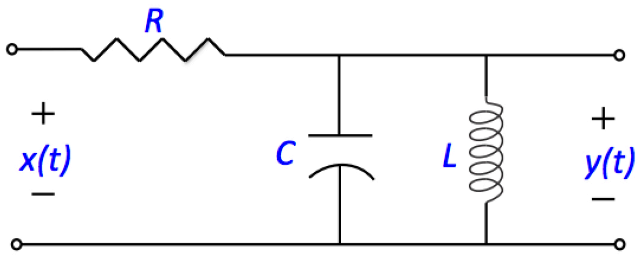
1. Following *RLC* circuit is described by the differential equation (1). Use Matlab built-in differential equation solver `dsolve()` to derive the impulse response *h(t)* for this circuit when $R=2\,\Omega$, $C=1F$, $L=0.5\ H$. Plot the impulse response $h(t)$ from a range $-10 \le t \le 30$.



$$RC\,\frac{d^2y(t)}{dt^2} + \frac{dy(t)}{dt} + \frac{R}{L}\,y(t) = \frac{dx(t)}{dt} \qquad \ldots (1)$$

2. Consider the following input signal

$$x_1(t) = \begin{cases} 5, & 0 \le t < 10 \\ 0, & \text{elsewhere} \end{cases}$$

$$x_2(t) = 2x_1(t-10)$$

$$x_{linear\_comb}(t) = x_1(t) + 2x_1(t-10)$$

Using the example Matlab file `simplified_convolution_runtime.m`, plot the output signals in three separate figure windows:

(a) $y_1(t) = x_1(t) * h(t)$

(b) $y_2(t) = x_2(t) * h(t)$

(c) $y_{linear\_comb} = x_{linear\_comb}(t) * h(t)$.

Use the ranges of 'τ' and 't' as $-10 \le \tau \le 40$ and $-10 \le t \le 40$. Also plot $y_3(t)=y_1(t)+y_2(t)$ and comment on similarity of $y_3(t)$ and $y_{linear\_comb}(t)$.

3. A single-tone signal $w(t) = \sin(400\pi t)$ is transmitted to an audio amplifier and speaker to produce a high-temperature warning for a silicon crystal-growing factory. A filter having impulse response $h(t) = 400e^{-200t}\cos(400\pi t)u(t)$ has been designed to reduce additive interference in the received signal. Using Matlab in-built convolution function: `conv()`, find the filter output signal $y(t)$, when the received signal is $x(t) = [\cos(100\pi t) + \sin(400\pi t) - \cos(800\pi t)]u(t)$ (signal $w(t)$ was corrupted by interference and resulted in an input signal $x(t)$). Plot the output signal, the input signal, and $w(t)$ for the range of $-0.1 \le t \le 0.1$. Comment on the effect of the filter on the signal. While solving this problem, pay attention to the time resolution/step (`dT`) you need to use.

4. System response for an Industrial Shock Absorber (figure below) can be modeled with the following differential equation:

$$M\frac{d^2y(t)}{dt^2} + b\frac{dy(t)}{dt} + ky(t) = r(t) \qquad ...(2)$$

Let's assume the mass of the damper M is $100\ kg$, the spring constant k is $1\ kgs^{-2}$, and the friction coefficient b is $20\ kgs^{-1}$. Using Matlab built-in differential equation solver `dsolve()` to derive the impulse response $h_1(t)$ for this Industrial Shock Absorber and the impulse response $h_1(t)$ from a range $-10s \le t \le 300s$. Overtime the oil inside the shock absorber degrades and the friction coefficient b becomes $0.2\ kgs^{-1}$. Derive the new impulse response $h_2(t)$ for this Industrial Shock Absorber and plot $h_2(t)$ from a range $-10s \le t \le 300s$.