Objective
Verify that the convolution of a circuit input with the circuit impulse response produces the circuit output.

Background
The circuit shown in Figure 1 has the following impulse response:

\[ h(t) = \frac{1}{RC} e^{-t/(RC)} u(t) \]  

Figure 1: First Order Lowpass Filter

The Octave/MATLAB function `ct_conv` can be used to compute the convolution of many functions for which the user can write a defining MATLAB function. For example,

\[[y t] = \text{ct\_conv}(@vexample, @hresp, [0 20e-3], 10e-6);\]

computes the convolution of the two waveforms defined in the MATLAB `vexample` and `hresp` functions. The first two arguments to `ct\_conv` are function handles. You create a function handle by adding an '@' symbol to the beginning of the function name. The third and fourth arguments cause the convolution to be computed over the interval 0 – 20 ms at 10 μs steps. The function returns the result vector y and the corresponding time vector t (the t vector contains the time values at which the convolution was computed). The result can be plotted by simply entering:

\[\text{plot}(t, y);\]

Procedure
1. Download the example driver script (`example.m`) and the input (`vexample.m` and `hresp.m`) function files from the course web site. The `example.m` script convolves the impulse response above (for \(R = 1k\Omega\) and \(C = 1\mu F\)) and a 5 V triangular pulse of 10 ms duration. Run the `example` script. Notice that it plots the input voltage and impulse response in the top row of the graph window while plotting the convolution in the bottom row. **You should not include the results from this step in your lab report.** This step is performed only to verify that the provided functions are working correctly.
2. Octave/MATLAB: Copy the `example.m` script to `script1.m`. Copy the `vexample.m` function to `vin1.m`. Modify `vin1.m` so that it defines a 15 V amplitude rectangular pulse of 10 ms duration. Modify `script1.m` so that it computes the convolution of `vin1` and `hresp`. It should plot both input functions and the result of the convolution as in the original `example` script.
3. LTspice: Use LTspice to find and plot the output of the circuit above (for \(R = 1k\Omega\) and \(C = 1\mu F\)) in response to a 15 V rectangular pulse of duration 10 ms. Be sure to specify an initial capacitor voltage of 0 V (even though this is the default). Perform a transient analysis and run the simulation out to 20 ms. Be sure to plot the input voltage to ensure that it is correct (you may need to specify small but non-zero rise and fall times for the input pulse).
4. Analysis: Use the convolution integral to convolve the theoretical impulse response and the 15 V pulse using the graphical method discussed in class and in the textbook. Plot your result in Octave/MATLAB for inclusion in your lab report.
5. Repeat steps 2 and 3 for a 1000 Hz sine pulse of 10 ms duration and 12 V amplitude. (Create new files `script2.m` and `vin2.m`) You do not need to compute the convolution analytically for this input.