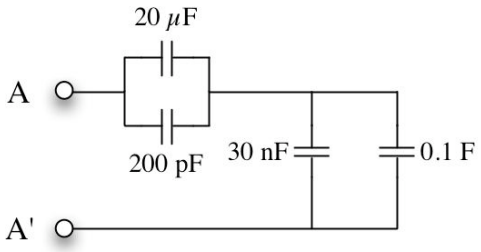
Homework #6 – March 18, 2009

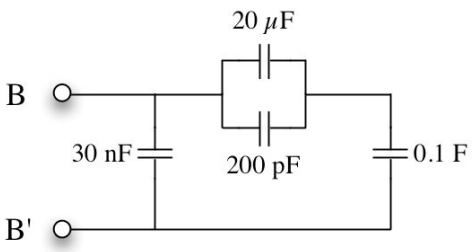
Due: April 1, 2009 at recitation

No late homework accepted

1. *[20 points]* Find the equivalent capacitance of the following two networks, (a) and (b):



(a)



(b)

2. *[20 points]* Exercise 10.16, p572 of Agarwal and Lang. (Note 'Exercise' not 'Problem')

3. *[20 points]* Exercise 10.20, p572 of Agarwal and Lang.

4. *[40 points]* This problem studies the response of a series RC network, both theoretically and experimentally. The experiments will be performed using the ELVIS iLab. The circuit to be studied is shown below. It comprises a capacitor, two resistors and a voltage source all in series, Figure 4.1. The voltage $v_{OUT}(t)$ across R_2 can be measured and used to determine the current through the series network.

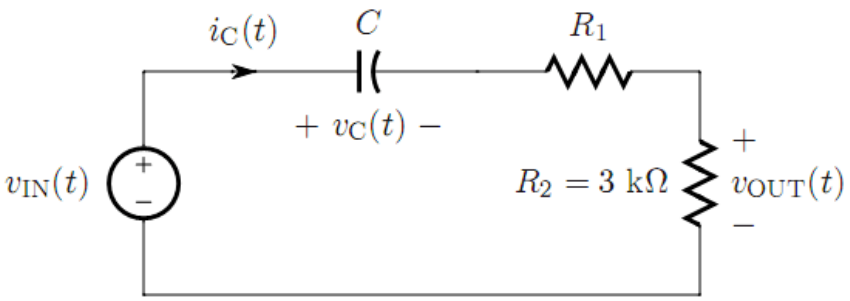
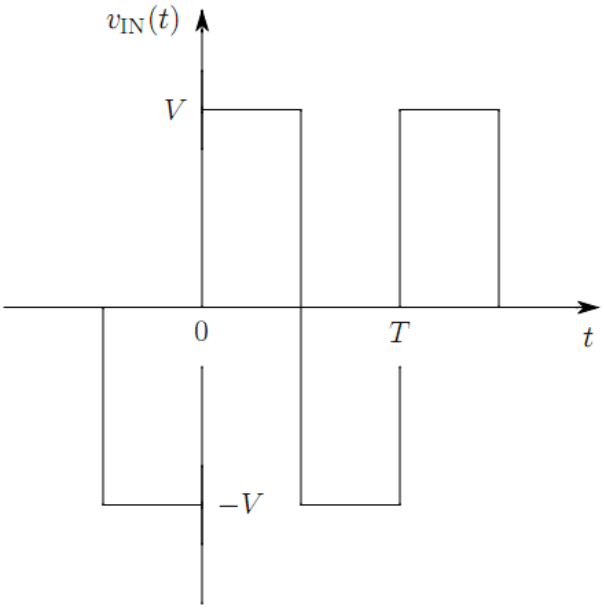


Figure 4.1

Consider first a theoretical study of the network. Let the voltage $v_{IN}(t)$ be a periodic square wave with amplitude V and period T as shown below. The period T is much larger that the RC time constant of the network. Assume that $v_{IN}(t)$ has been applied long before t = 0, while any measurements start at t = 0. Thus, the network has reached its periodic steady state before any measurements are taken.



a) Derive an expression for $v_C(t)$, the voltage across the capacitor. Your answer should include separate expressions for the time period over which $v_{IN}(t) = V$, and the time period over which $v_{IN}(t) = -V$. Hint: consider the consequences of T being much longer than the RC time constant of the network, and use reasonable engineering judgment.

b) Derive an expression for $i_C(t)$, the current flowing through network.
c) Derive an expression for $v_{OUT}(t)$, the voltage across R_2.

Now consider an experimental study of the network. First, log in to the ELVIS iLab as in previous homeworks. After launching the iLab, you should see a network that is equivalent to the one shown above.

First, select the voltage source, or FGEN signal generator, and set its parameters to WaveForm = SQUARE, Frequency = 200 Hz, Amplitude = 1 V, and O□set = 0 V. Second, select the SCOPE output measurement unit and program it with a suitable sampling rate that will allow you to see at least one full cycle of $v_{OUT}(t)$ with enough resolution. Note that the system will only allow you to take a maximum of 201 data samples at the output. Third, run the experiment. Finally, select $v_{IN}(t)$ for the Y1 axis and $v_{OUT}(t)$ for the Y2 axis, and use linear axes for both. When the figure resembles what you expect, capture a screen shot for subsequent analysis.

d) From the experimental data, extract the *RC* time constant of the network. You can see the actual numerical values of the data that you have obtained by looking into *View Data* under the *Results* menu. You can also download the data to Excel using the *Results* menu
e) From the experimental data, extract the value of the resistor R_1. When you do this, note that even though you selected 1 V as the amplitude, the signal generator does not impose this voltage very accurately; the actual amplitude is measured as v_{IN}.
f) From the experimental data, extract the value of *C*.