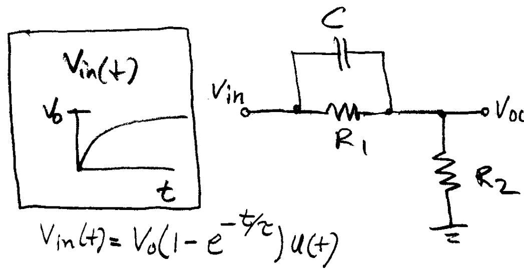
Physics 116B Winter 2007: Quiz 1 “Clinic” - 1/29/2007

Closed book and notes. Work in groups of 3-4. Make sure everyone understands and agrees with what is written down. Show reasoning. I am available to provide or verify some information. Could it help your understanding if I answered a question with a question? **Be sure to put your names on your paper.**

Note: complex quantities are shown in **boldface** type.



1. In the network above, the voltages and currents are zero for $t < 0$. The input waveform is

$$v_{\text{in}}(t) = V_0(1 - e^{-t/\tau})u(t).$$

A sketch of the input waveform is shown in the inset.

(a) Find $\mathbf{Z}(\mathbf{s})$ for the parallel combination of R_1 and C.

(b) Find $\mathbf{H}(\mathbf{s}) \equiv \mathbf{v}_{\text{out}}/\mathbf{v}_{\text{in}}$ for the circuit.

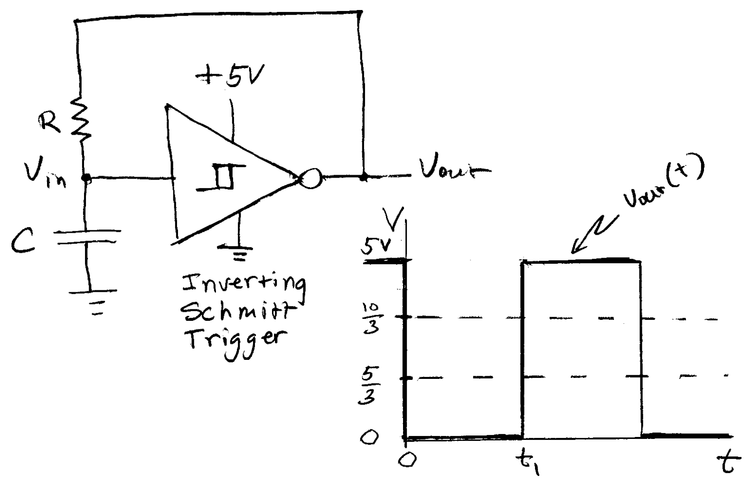
(c) From the augmented Laplace table, one can find

$$\mathbf{v}_{\text{in}}(\mathbf{s}) = \frac{V_0/\tau}{\mathbf{s}(\mathbf{s} + 1/\tau)}.$$

Now choose R_1 and C such that $R_1C = \tau$, the time constant of the input waveform. Also choose $R_2 = R_1/9$. Show that

$$\mathbf{v}_{\text{out}}(\mathbf{s}) = \frac{V_0}{\mathbf{s}(\tau\mathbf{s} + 10)}.$$

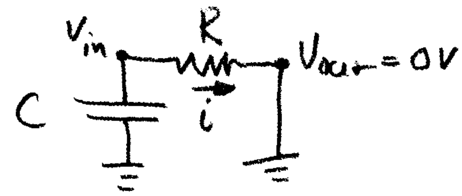
(d) Find $v_{\text{out}}(t)$. How does (i) the pulse height and (ii) the time constant of the output waveform compare with that of the input?



2. The circuit above shows an inverting Schmitt trigger connected to an RC network to make a relaxation oscillator. The output "bubble" denotes logic negation so the actual hysteresis curve is inverted with respect to the symbol on the diagram. The output logic levels are 0 V and 5 V. The input threshold for the output low to high transition is 5/3 V and 10/3 V for high to low. A sketch of one cycle of the output waveform after the oscillator has been running for a while is also shown.

   (a) Make a graph of the hysteresis curve V_{out} vs. V_{in} for the Schmitt trigger.

   (b) Show that the network is equivalent to the following circuit for $0 < t < t_1$.



   (c) FInd V_{in} when (i) $t = 0$ and (ii) $t = t_1$. Explain your reasoning.

   (d) Find an expression for $v_{\text{in}}(t)$ for $0 < t < t_1$ in terms of R and C. Note that this does not have "zero initial conditions."

   (e) Find t_1 in terms of R and C.

   (f) Find the equivalent circuit and repeat for $t_1 < t < t_2$.

   (g) Sketch $v_{\text{in}}(t)$ on the waveform plot for the full cycle of oscillation.

   (h) Find the frequency of oscillation.