

University of California at Berkeley
College of Engineering
Department of Electrical Engineering and Computer Sciences

EECS150
Spring 2002

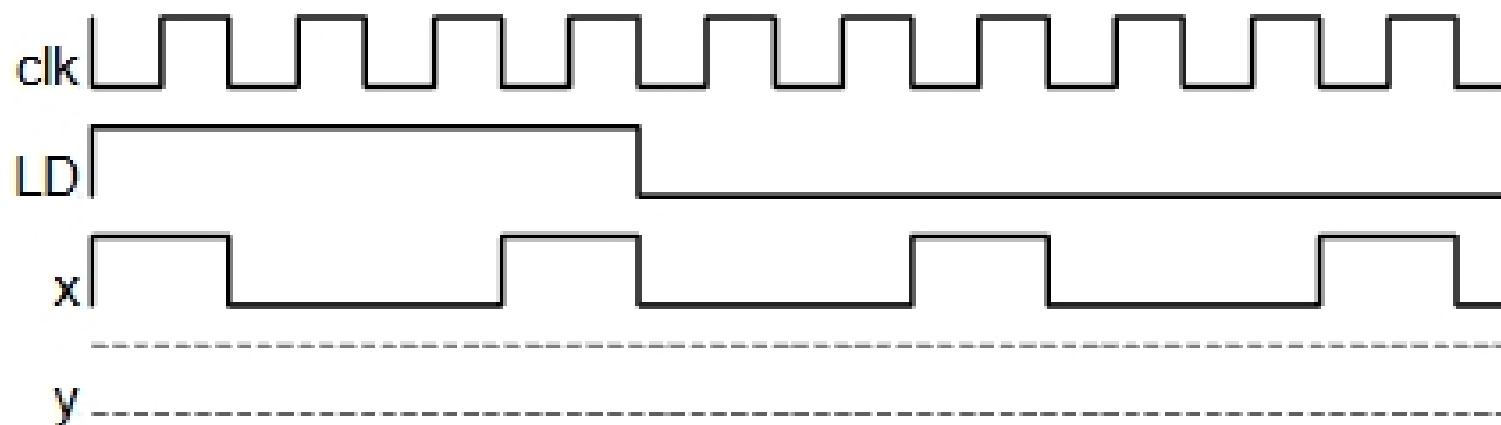
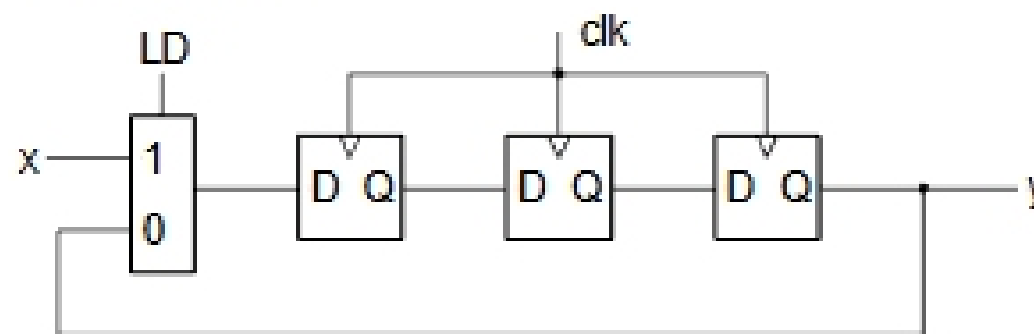
J. Wawrzynek

Homework #2

This homework is due on **Friday Feb 8th by noon**. Homework will be accepted in the EECS150 homework box outside 218 Cory Hall. Late homework will be penalized by 50%. No late homework will be accepted after the solution is handed out.

1. Flip-flops and timing.

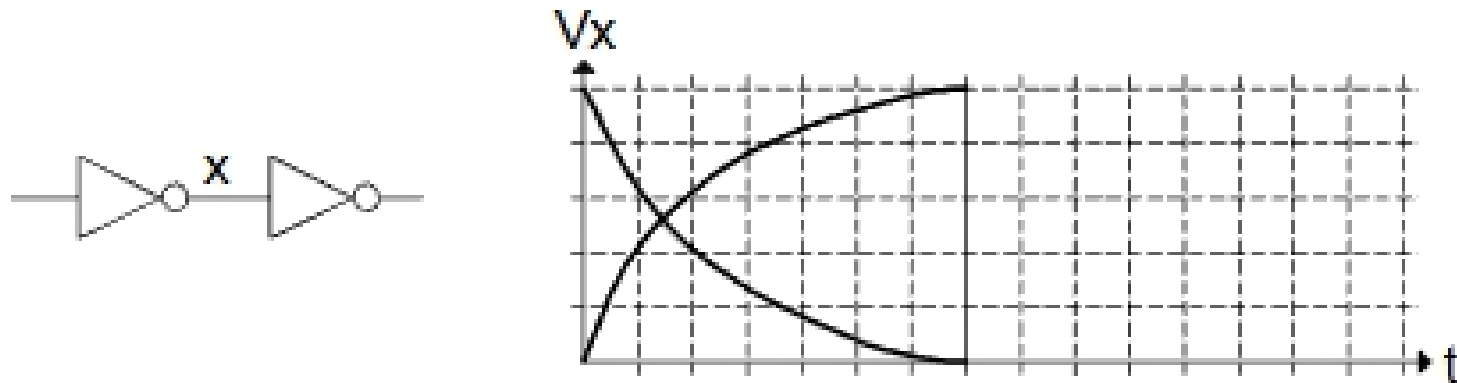
a) For the circuit shown, assume that all the flip-flops initially hold logic 0. Draw the waveform that appears at point *y*.



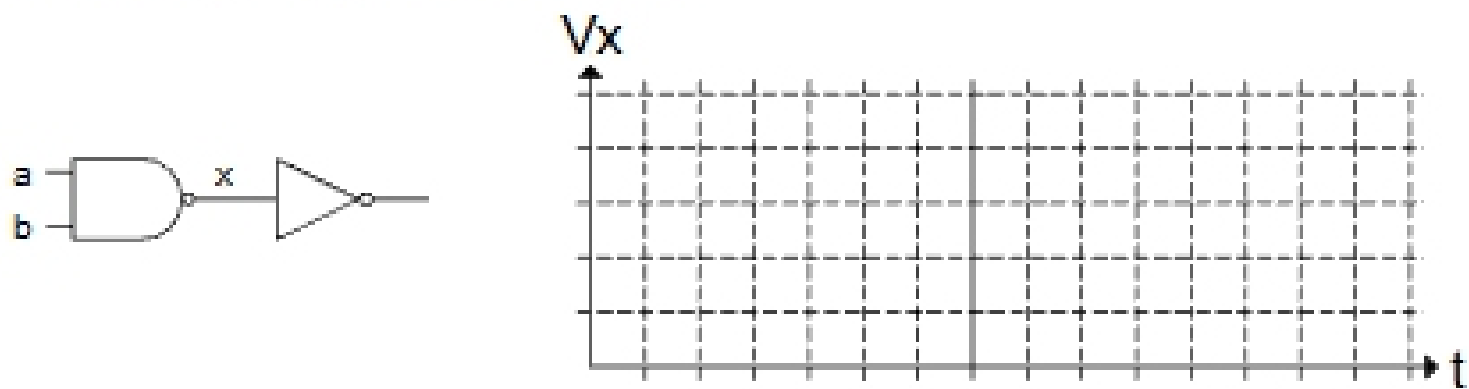
b) Assume the flip-flop setup time is 75ps and its clock-to-Q delay is 100ps. If the mux propagation delay is 150ps, what is the maximum clock frequency for this circuit?

2. Logic gate timing waveforms.

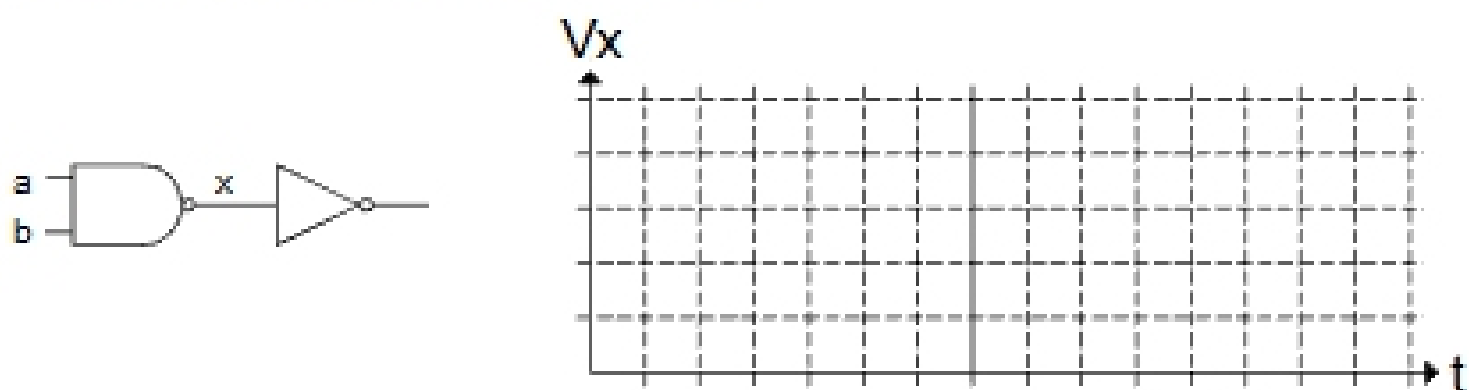
Below is shown the waveforms corresponding to a low-to-high and a high-to-low transition for an inverter. Draw approximate transition waveforms for the other situations shown below. Assume that all transistors in all the gates and inverters are of the same strength.



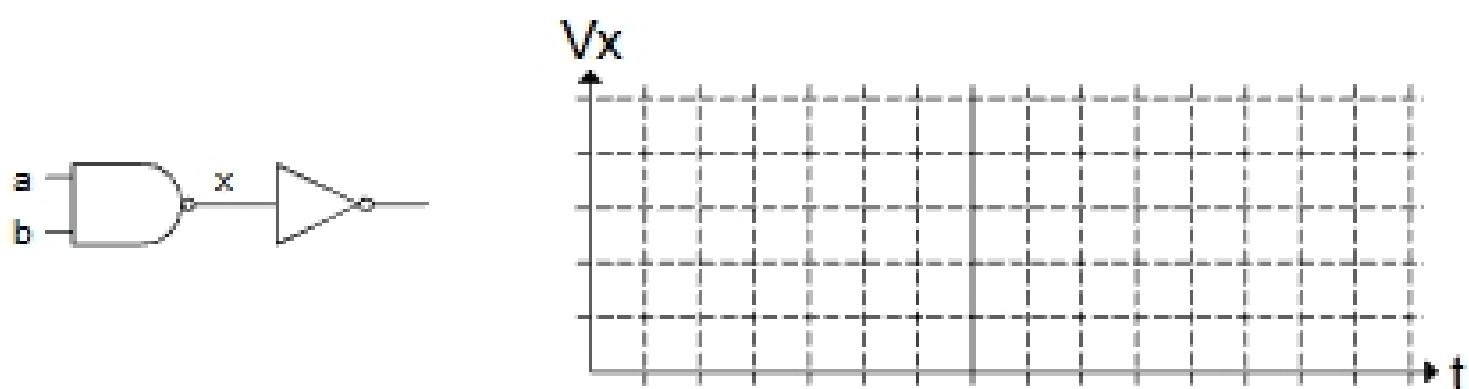
a) V_x initially is high, set $a=b$ =high.



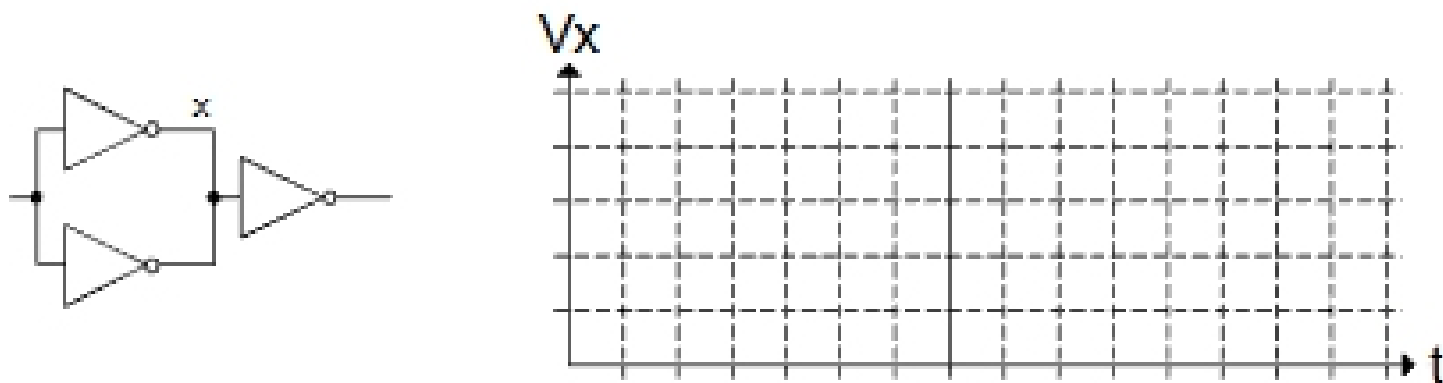
b) V_x initially is low, set a =high, b =low



c) V_x initially is low, set $a=b$ =low.



d) Show both transitions.



3. Gate delay.

Consider a CMOS AND gate constructed as a NAND gate followed by an inverter.

Assume the inverter propagation delay is expressed as follows:

$$\tau_p = 50 + 100 \cdot f$$

where f is the fanout of the inverter, expressed in number of transistor-gate inputs (inverters contribute 2 to f , one input of 2-input gates contribute 2,). Assume this inverter has the same propagation delay for both low-to-high and high-to-low transitions.

The NAND gate propagation delay is expressed as:

$$\tau_{PLH} = 100 + 75 \cdot f$$

$$\tau_{PHL} = 100 + 125 \cdot f$$

For the low-to-high and high-to-low transitions, respectively. Write expressions for the propagation delay of the AND gate:

$$\tau_{PLH} =$$

$$\tau_{PHL} =$$