Outline

- ❏ Digital CMOS design
  - ○ Boolean algebra
  - ○ Basic digital CMOS gates
  - ○ Combinational and sequential circuits
  - ○ Coding - Representation of numbers

CMOS Circuits

○ **Combinational logic**

The value of the output can be determined knowing the value of the inputs

○ **Sequential logic**

The value of the output depends on the value of the inputs and the history

Notion of memory

CMOS Circuits

Memory :

Hold a data (0 or 1)

Write a data (0 or 1)

qn   q
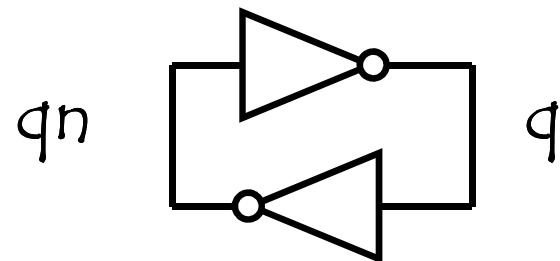
CMOS Circuits

Memory :

Hold a data (0 or 1)
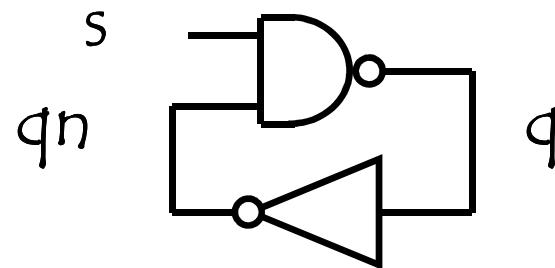
Write a data (0 or 1)

s	q	qn
O	1	O
1	q	qn

CMOS Circuits

Memory :

Hold a data (0 or 1)
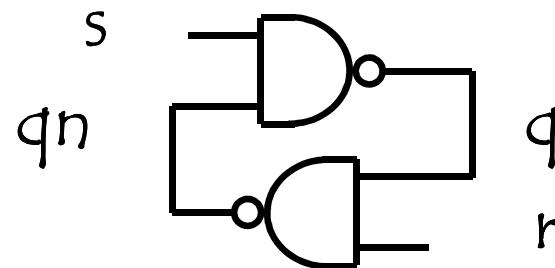
Write a data (0 or 1)

s	r	q	qn
0	1	1	0
1	0	0	1
1	1	q	qn
0	0	1	1

RS flip flop

CMOS Circuits

Synchronous Memory :

Write a data d when the clock $ck = 1$

s	r	q	qn
0	1	1	0
1	0	0	1
1	1	q	qn
0	0	1	1

q

qn

d latch
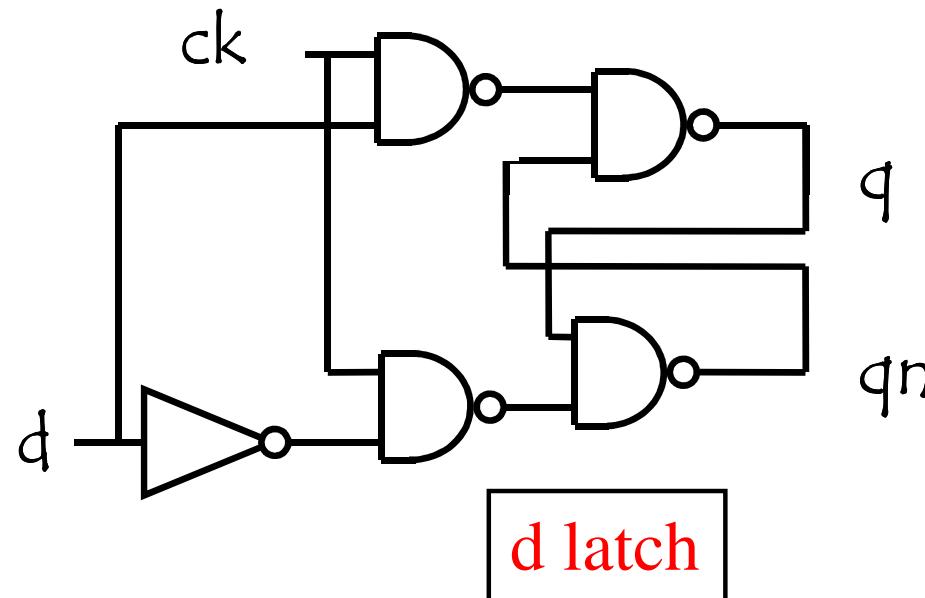
if $ck.d = 1$ s = 0

if $ck.\overline{d} = 1$ r = 0

CMOS Circuits

Synchronous Memory :

Write a data d when the clock ck = 1
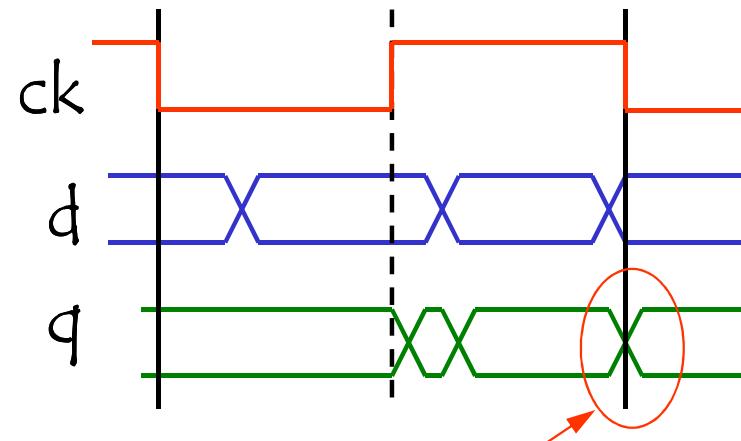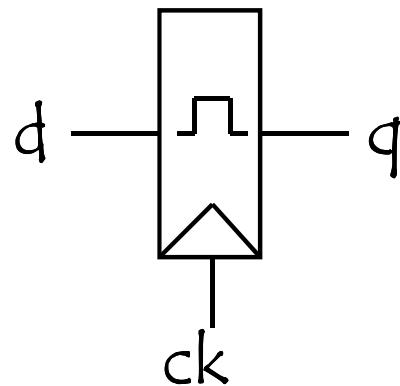
hazardous

CMOS Circuits

Synchronous Memory :

setup time

hold time

ck

d

q

ck
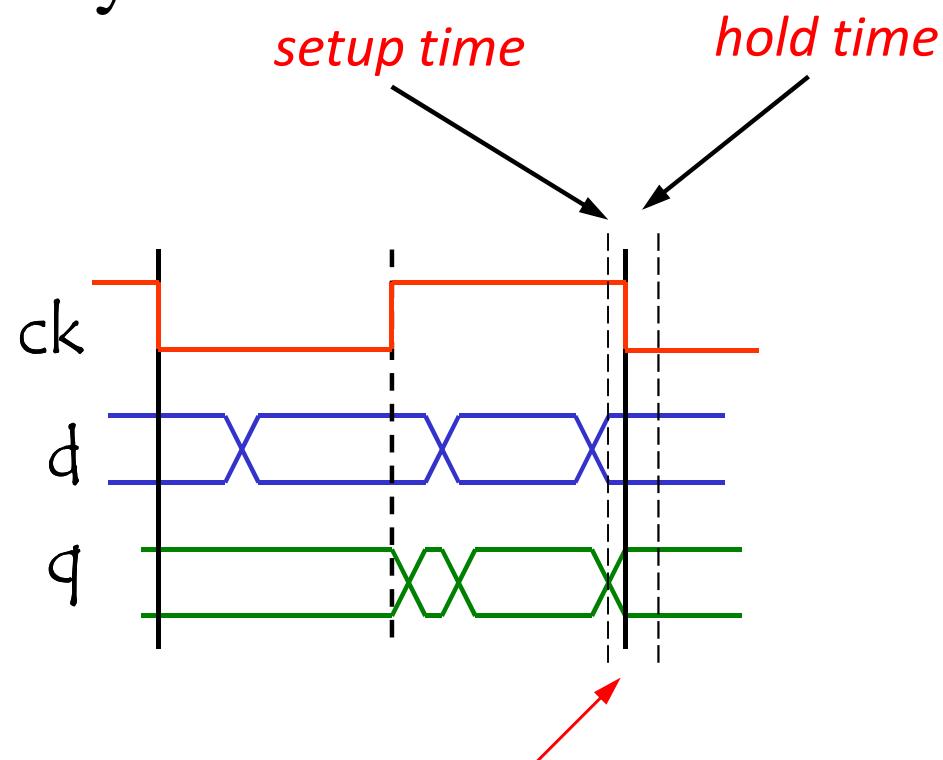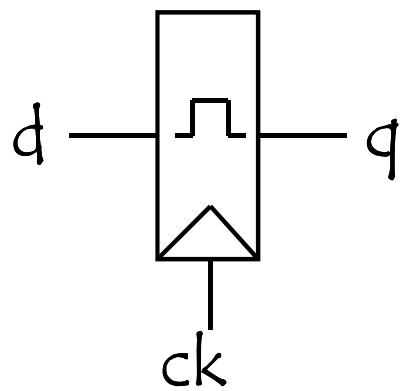
data should not be changed during this period

CMOS Circuits

Memory :

s	r	q	qn
0	1	0	1
1	0	1	0
1	1	0	0
0	0	q	qn

RS flip flop

Synchronous Memory :

Write a data d when the clock ck = 0

d latch
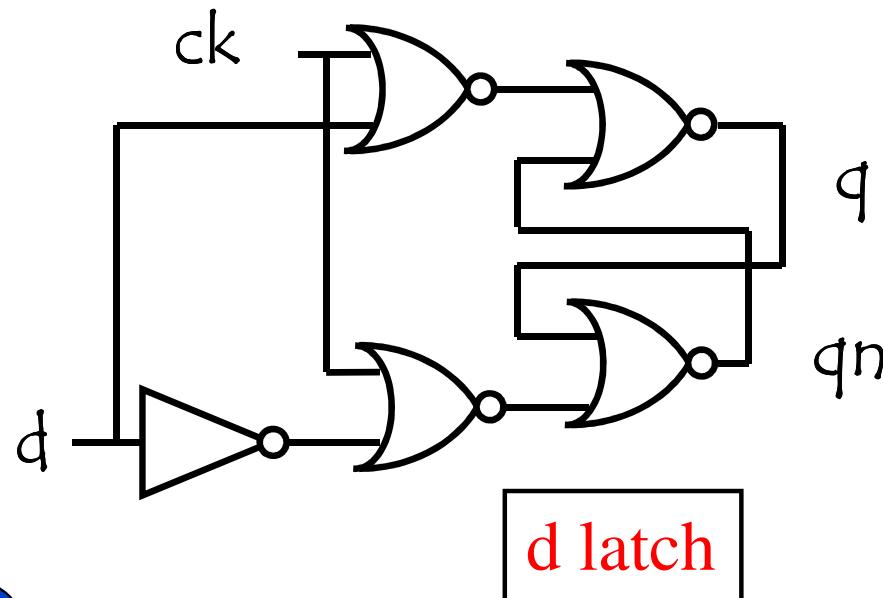
s	r	q	qn
0	1	0	1
1	0	1	0
1	1	0	0
0	0	q	qn

if $\overline{ck}.d = 1$ s = 1

if $\overline{ck}.\overline{d} = 1$ r = 1

CMOS Circuits

Synchronous Memory :
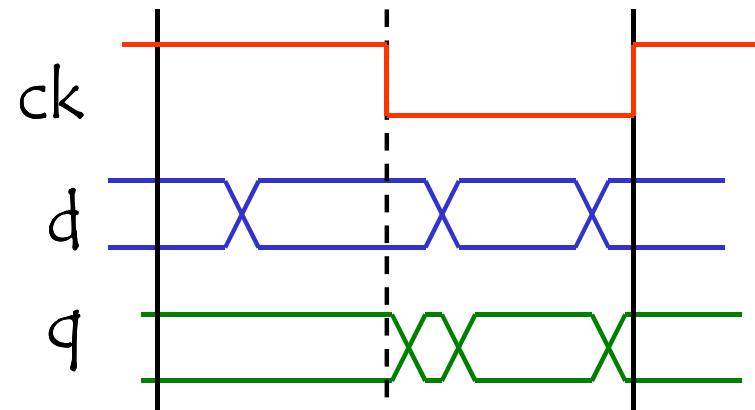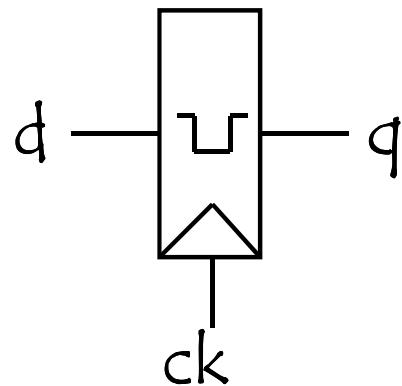
Write a data ɖ when the clock ck = O

CMOS Circuits

Synchronous Memory :

Write a data d on the rising edge of the clock ck

CMOS Circuits

Synchronous Memory :

Write a data d on the rising edge of the clock ck

CMOS Circuits

Synchronous Memory :

Write a data d on the rising edge of the clock ck

δ should be > Δ
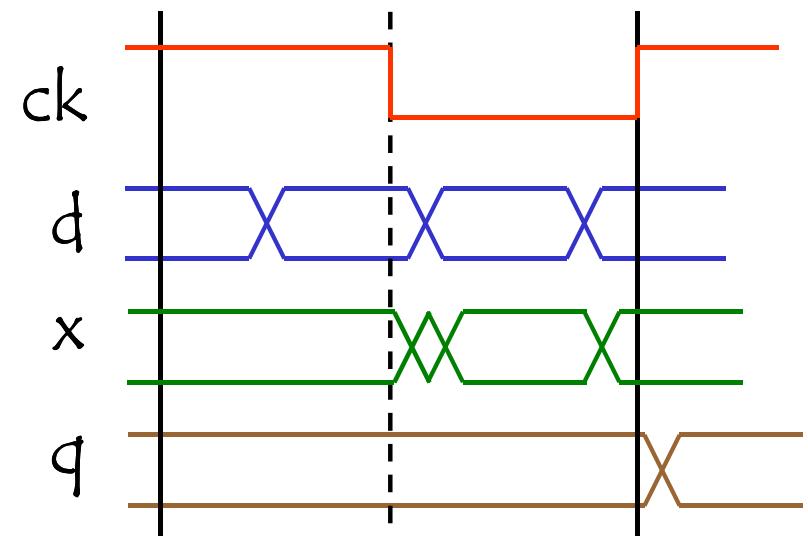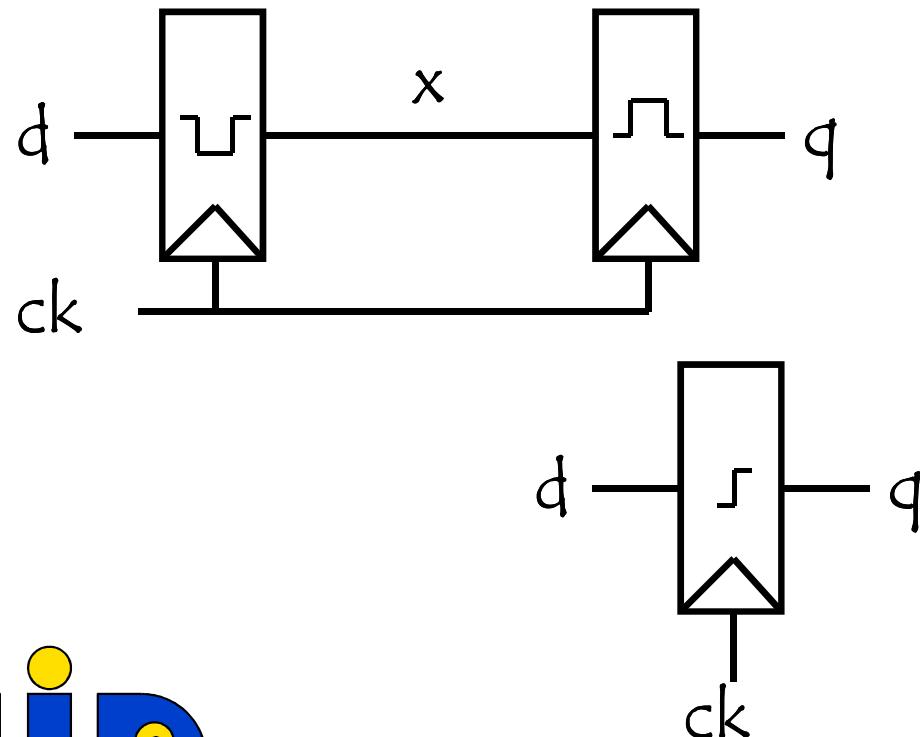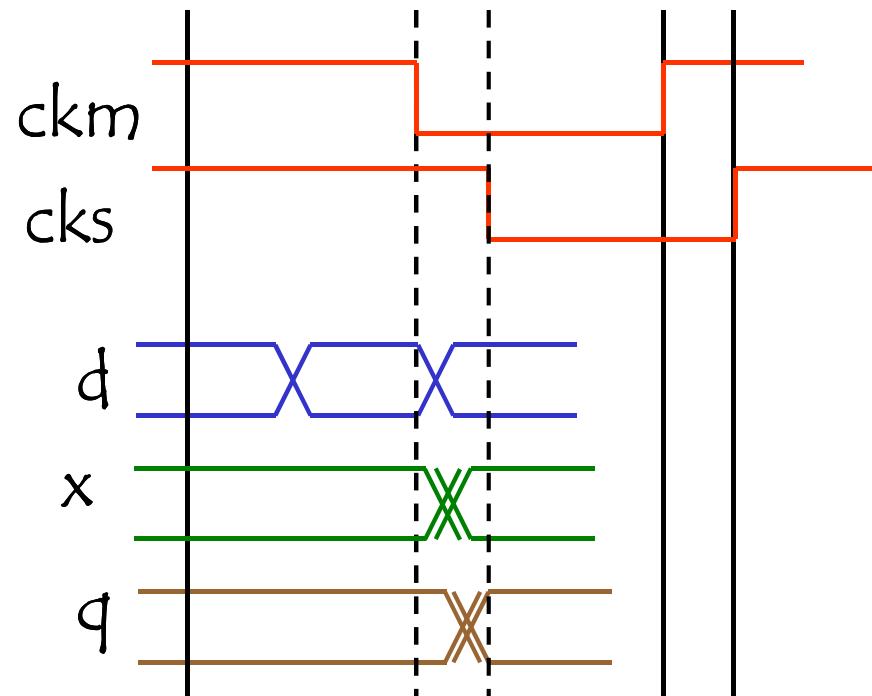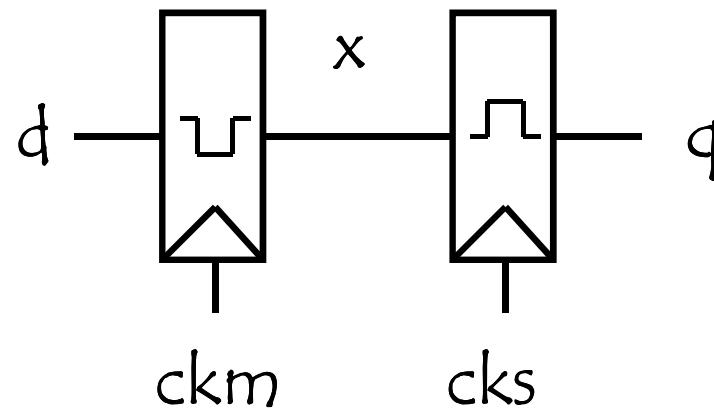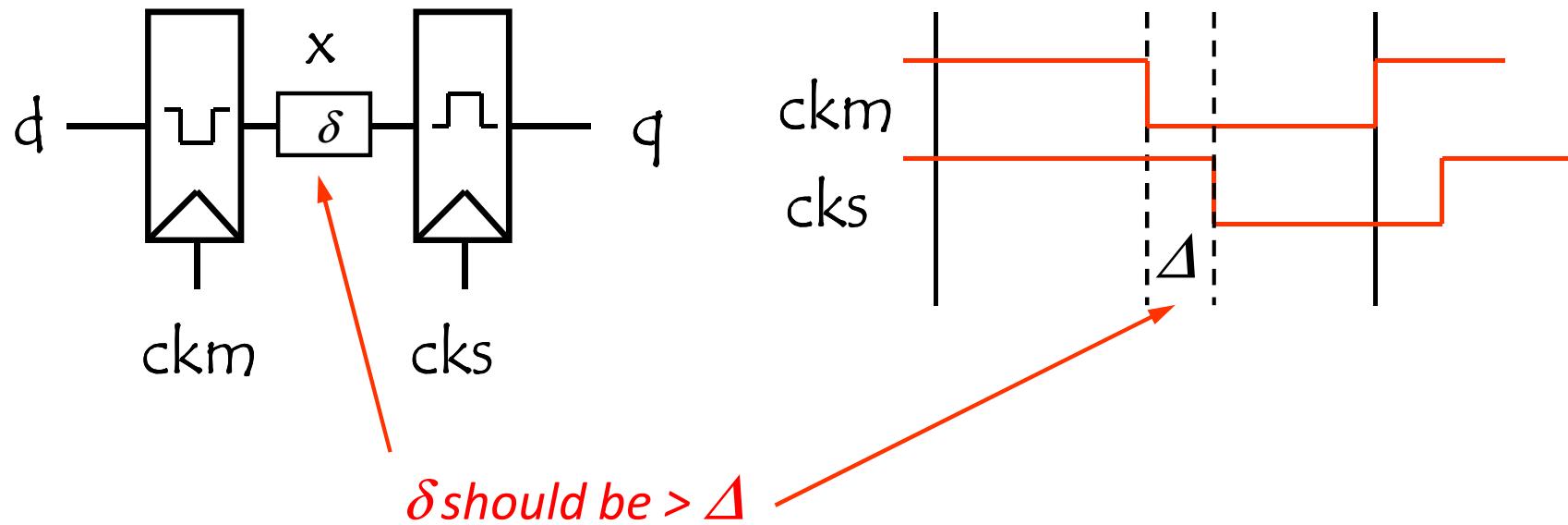
CMOS Circuits

Synchronous Memory :

Write a data d on the falling edge of the clock ck
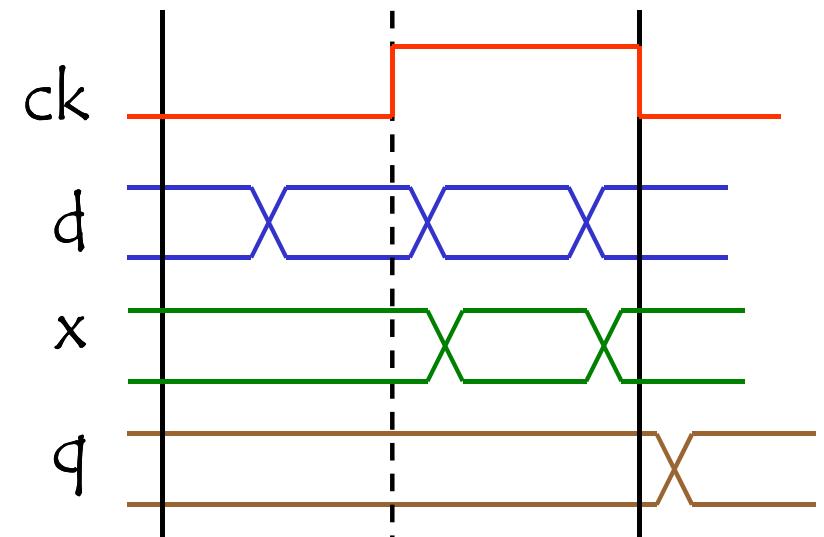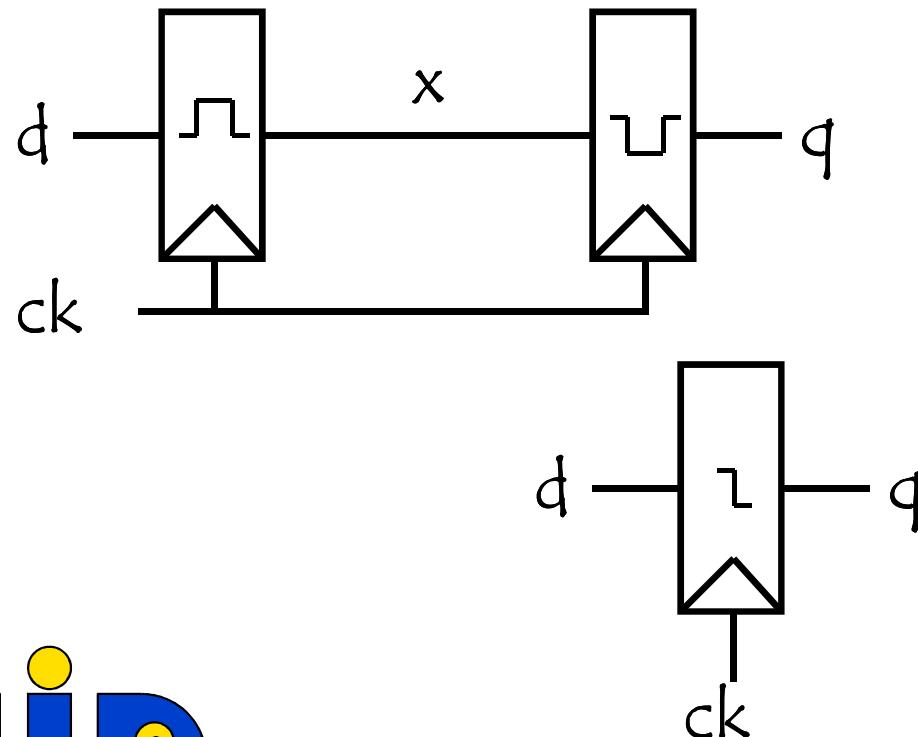
CMOS Circuits

Synchronous Memory :

Write a data d on the rising edge of the clock ck
when a condition is true (write enable)

CMOS Circuits

Synchronous Memory :

Write a data d on the rising edge of the clock ck
when a condition is true (write enable)