Section 4B Worksheet Solutions

Problem 1

BUF

A	Y
0	0
1	1

NOT

A	Y
0	1
1	0

OR

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

AND

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

NAND

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

NOR

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

XOR

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

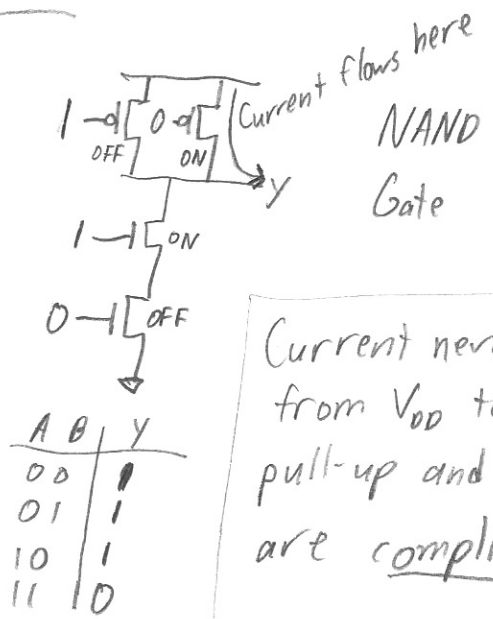
XNOR

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

NOR3

A	B	C	Y
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

Problem 2

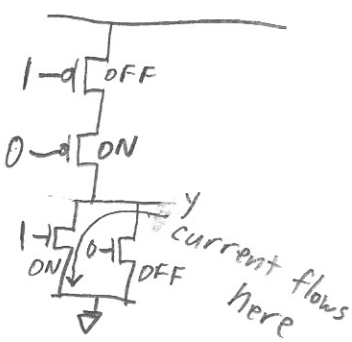


NAND Gate

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Current never flows directly from V_{DD} to GND because the pull-up and pull-down networks are complimentary.

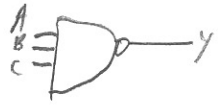
NOR Gate



A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

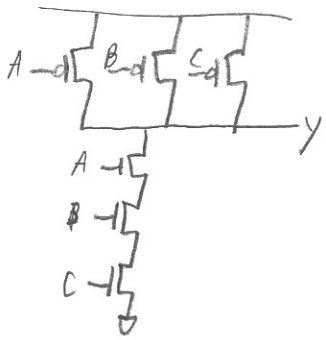
Problem 3

a)



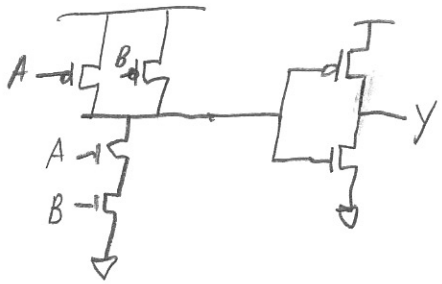
$Y = \overline{ABC}$

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0



b) You cannot build an AND gate in a single stage because the pull-up and pull-down networks are inverting. (You cannot use nMOS devices in the pull-up network or pMOS devices in the pull-down network.)

You can build AND as NAND followed by INV:



Problem 4

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

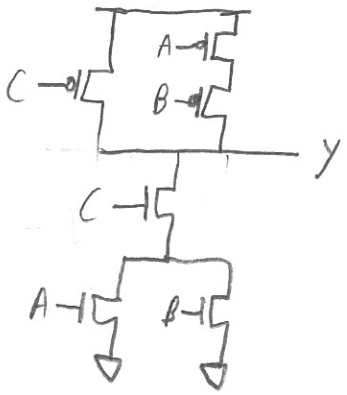
$Y = A\bar{B} + \bar{A}B = A \otimes B$

Problem 5

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

"or-and-invert"

OAI



Problem 6

a)

A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

b)

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

c)

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

Problem 7

B_0	B_1	B_2	$\overline{B_0 B_1 B_2}$	$\overline{B_0} + \overline{B_1} + \overline{B_2}$
0	0	0	$\overline{0 \cdot 0 \cdot 0} = 1$	$\overline{0} + \overline{0} + \overline{0} = 1$
0	0	1	$\overline{0 \cdot 0 \cdot 1} = 1$	$\overline{0} + \overline{0} + \overline{1} = 1$
0	1	0	$\overline{0 \cdot 1 \cdot 0} = 1$	$\overline{0} + \overline{1} + \overline{0} = 1$
0	1	1	$\overline{0 \cdot 1 \cdot 1} = 1$	$\overline{0} + \overline{1} + \overline{1} = 1$
1	0	0	$\overline{1 \cdot 0 \cdot 0} = 1$	$\overline{1} + \overline{0} + \overline{0} = 1$
1	0	1	$\overline{1 \cdot 0 \cdot 1} = 1$	$\overline{1} + \overline{0} + \overline{1} = 1$
1	1	0	$\overline{1 \cdot 1 \cdot 0} = 1$	$\overline{1} + \overline{1} + \overline{0} = 1$
1	1	1	$\overline{1 \cdot 1 \cdot 1} = 0$	$\overline{1} + \overline{1} + \overline{1} = 0$

We have shown the equality to be true for all possible values of B_0, B_1, B_2, so the theorem is proven by perfect induction. ∎