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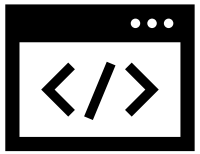

BIOE40002 – Computer Fundamentals and Programming 1

Part I – Digital Logics, Lab 3

Binghuan Webster Li | *Department of Bioengineering*

binghuan.li19@imperial.ac.uk

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Corrections

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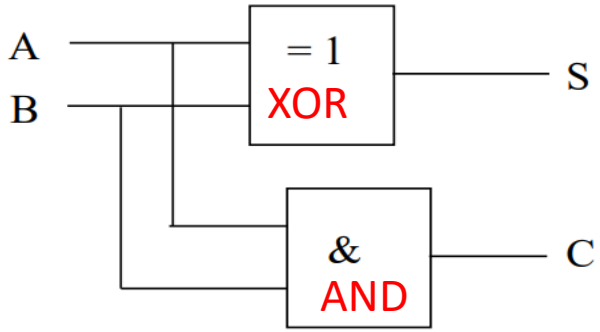
1. Half adder: the combination of an *AND* gate and an *XOR* gate



2. Quiz 1, statement 1: ***not true!***

*A half adder is constructed with a XOR gate and an **OR** gate*

Meme of the day…

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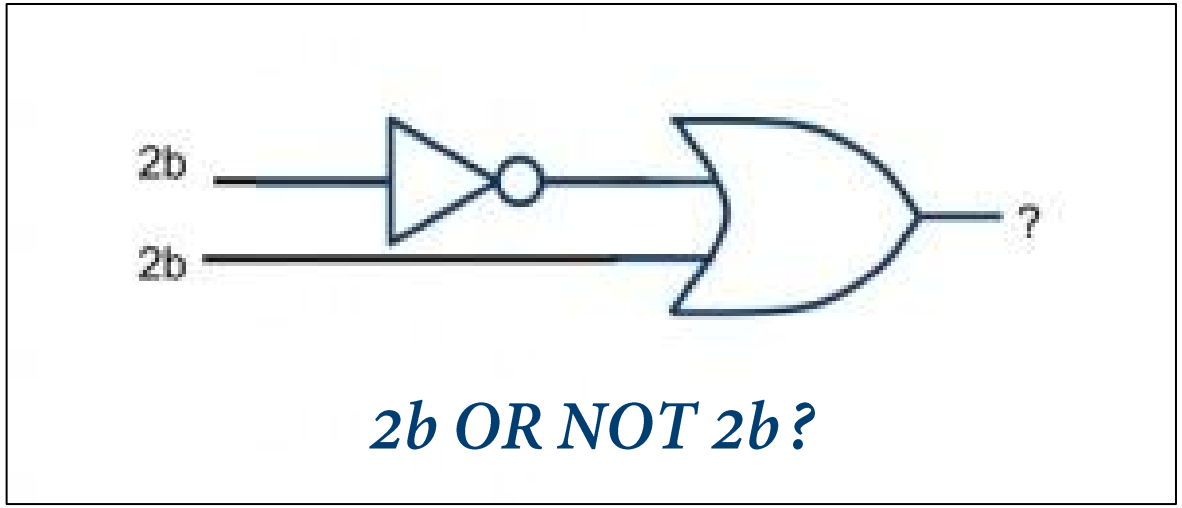
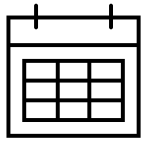
Give a name to this circuit.





Today's Schedule

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- Recap (~ 10 mins)
  - 4-bit addition machine
  - Signed binary representation
  - Binary substruction
- Lab exercises 8, 9, 10
- Quiz time !

4-bit addition machine

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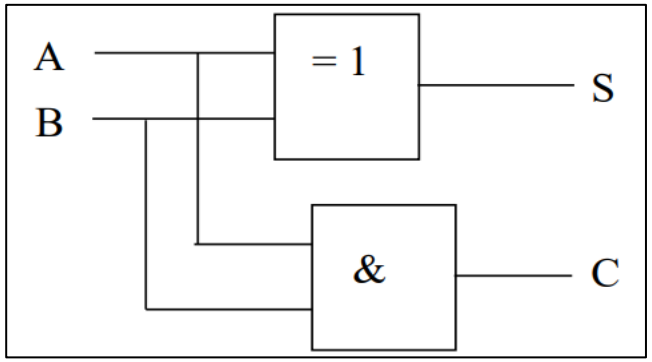
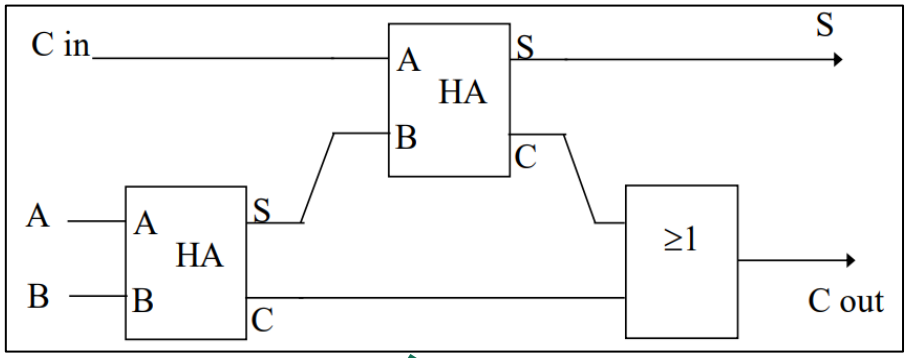
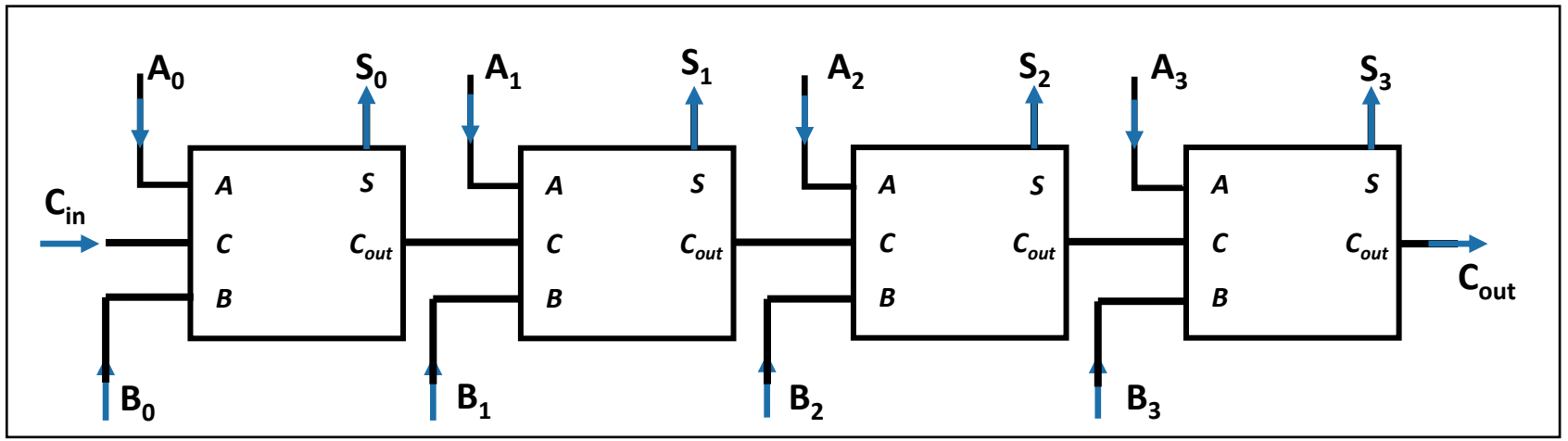
2-bit half adder



2-bit full adder



4-bit full adder



Signed binary representation

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- ***Q:*** How to represent a negative number in the binary form?
- ***A:*** signed binary numbers
- ***Key rule:*** let the most significant bit represent a negative number, -2^n

Example: convert $(-11)_{10}$ into the binary form

- Step 1: strip down $(-11)_{10}$ into the sum of 2^n

$$(-11)_{10} = -16 + 4 + 1$$

- Step 2: express each presented term as 1

	-2^4	2^3	2^2	2^1	2^0
Presented?	YES	NO	YES	NO	YES
Binary	1	0	1	0	1

- Therefore, $(-11)_{10} = (10101)_2$

Binary subtraction

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- ***Rationale:*** subtraction is equivalent to the addition of a negative value.

$$7 - 5 = 7 + (-5)$$

Example: $7 - 5$

- Step 1: Convert each term on L.H.S into the signed binary and perform addition

$$7 - 5 = 7 + (-5) = (0111)_2 + (1011)_2$$

- Step 2: Discard the most significant bit in the result

$$(0111)_2 + (1011)_2 = (\cancel{1}0010)_2$$

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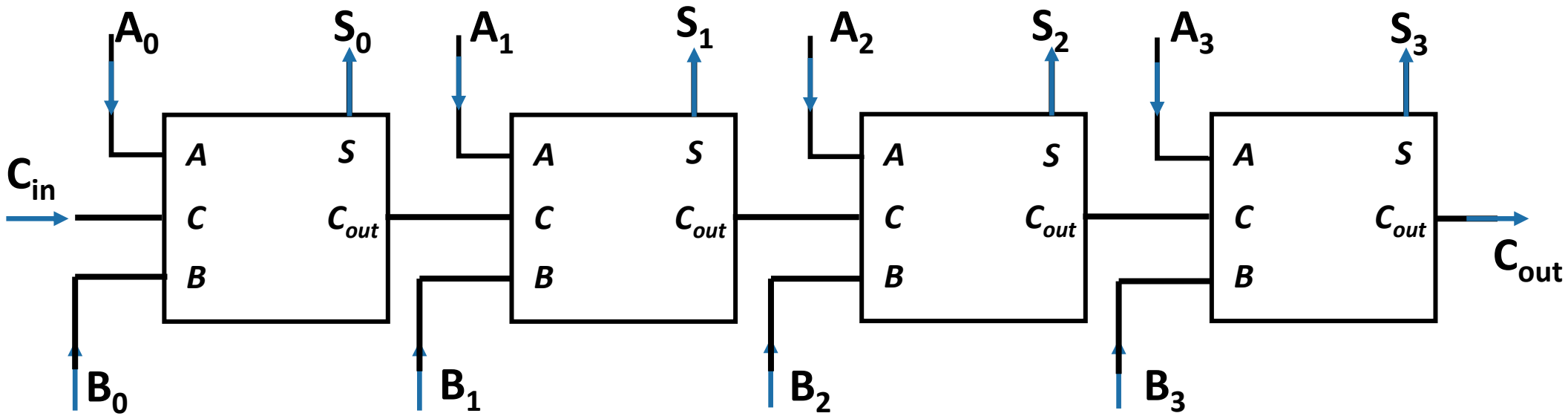
Questions?

That's it for now.

You can now proceed to the Exercise 8, 9 and 10.

Task 8 - design a 4-bit addition circuit



- Verification:

	Name	Value at 0 ps
in	A	B 0111
in	B	B 0001
in	Cin	B 0
out	Cout	B 0
out	S2	B 1000

	Name	Value at 0 ps
in	A	B 1101
in	B	B 0010
in	Cin	B 0
out	Cout	B 0
out	S2	B 1111

	Name	Value at 0 ps
in	A	B 1111
in	B	B 0001
in	Cin	B 0
out	Cout	B 1
out	S2	B 0000

A	B	S	Cin	Cout
0111	0001	1000	0	0
1101	0010	1111	0	0
1111	0001	0000	0	1

Task 9 – Signed binary calculation

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- Write down the binary equivalent of -3 and -5.

$$(-3)_{10} = 101$$

$$(-5)_{10} = 1011$$

- Perform the additions of 1+(-1) and 3+(-7) in binary.

$(1)_{10}$	0 1	$(3)_{10}$	0 0 1 1
$(-1)_{10}$	1 1	$(-7)_{10}$	1 0 0 1
$3_{10} + (-7)_{10}$	~~1~~ 0 0	$3_{10} + (-7)_{10}$	0 1 0 0

* Discard the most significant bit (MSB)

Task 10 - design a 4-bit subtraction circuit

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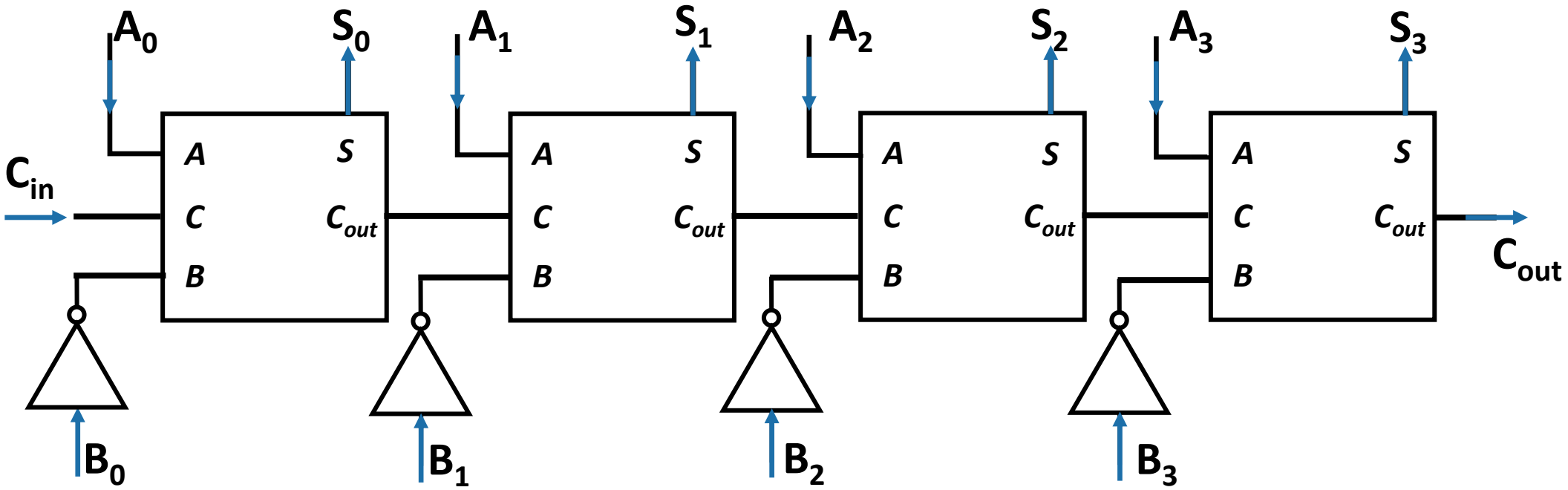
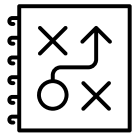


- The 4-bit subtraction circuit is obtained by inverting four B inputs.

- Verification:

	Name	Value at 0 ps
in	A	B 1101
in	B	B 0010
in	Cin	B 0
out	Cout	B 1
out	S2	B 1010



Quiz Time!

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1. Which of the followings is/are NOT true about 2's complement signed number representation?

(a) It can represent positive numbers

(b) It only represents negative numbers

(c) With 2's complement form, binary subtraction can be achieved using the addition machine

(d) Inverting every bit of a number and adding 1 will generate a negative number

2. Which of the following signed binary number(s) has/have a value that is closest to -1 in 2's complement form

(a) 10111 **(b)** 01100 **(c)** 11101 **(d)** 10000