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HW13: ALU and Control Unit

Each of these problems are based on the student designed ALU and Control Unit from the class YouTube video stream (videos 4000 and 4100). Review those videos thoroughly to answer these questions correctly.

1) Write a sequence of instructions to subtract register B from register A, storing the results in register C.

C <- A - B :

INVB: C <- $\overline{B}$
ADD: C <- A + C

2) Write a sequence of instructions to implement the logical equivalent of the Boolean expression $C \leftarrow A\,\overline{B}$.

INVB: C <- B
AND: C <- AC

3) Imagine our ALU/CU has been increased in size to work on 3 bit inputs and outputs, but has the same set of instructions as before. Write a sequence of instructions to perform the equivalent of RORA to rotate the contents of A to the right one bit, storing the result in register C. ***Hint***: if you rotate left enough, you'll have rotated right :-)

1 2 3 -> 3 1 2 -> 2 3 1

ROLA: C <- A
ROLA: C <- C

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4) Assuming you have a 4 bit version of our ALU with the same instructions and control operations, write a sequence of instructions to perform the following **C code**. X, Y and Z are variables in memory.

Z = X & (2 + ~Y);

Y = INVY : Y <- $\bar{Y}$
Z <- 10
Z = ADD: ZY
Z = AND: Z <- ZX

5) Imagine our ALU has been increased in size to work on 3 bit inputs and outputs, but has the same set of instructions as before. Follow the given instruction sequence to determine the 3 bit contents of each register A--C at the end of the code. If you know the bit is a 1 or 0, write a 1 or 0 respectively. If you know the bit is the middle bit of the original value of A, write A_1 for that bit (as opposed to A_2 or A_0). Eg. if the only instruction was ROLA, C would contain $A_1A_0A_2$.

	A	B	C
SWAP	C	A	B
ROLA	C_0 C_2 C_1	A	B
A ← C	B	A	B
SWAP	B	B	A
A ← 110_2	1 1 0	B	A
AND	0	$B_1 \cap B_2 \cap B_0$	$A_0 \cap A_1 \cap A_2$
Final values:	0	$B_0 \cap B_1 \cap B_2$	$A_0 \cap A_1 \cap A_2$

* How to swap was ambigious, ie, whether SWAP ABC yields CAB or BCA, just picked one
* Confused on the and instruction here, it needs 3 arguments here, inferring that for each register it ands the 3 bits located in that register.

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EXTRA CREDIT

6) Imagine our ALU has been increased in size to work on 3 bit inputs and outputs, but has the same set of instructions as before. Draw the complete circuit diagram below for the 3 bit ALU. Don't forget the flag bits (Carry, Sign and Zero).