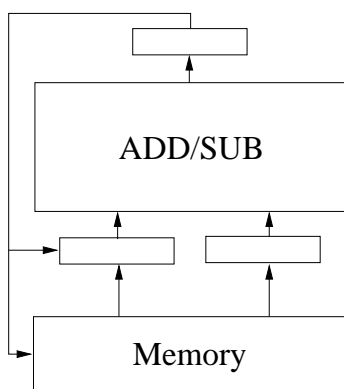


## CS2017 Assignment 6

### Diagram for Questions

Below is a simple circuit. It consists of a **memory** with 16 memory spaces (from M1 to M16), an **ALU block**, 2 **input registers** (IA and IB) and one **output register** (OUT). M1 to M16, IA, IB and OUT are all 8 bits long. Numbers are represented in *2's complement* format.



Nine commands (MOV, ADD, SUB, MUL, DIV, CMP, SHL, SHR and DEF) are provided for instructing the above circuit. The syntax and the descriptions of these commands are depicted in the following table.

Syntax	Description
MOV X Y	Copy the content of Y to X
ADD X Y	$OUT = X + Y$ .
SUB X Y	$OUT = X - Y$ .
MUL X Y	$OUT = X \times Y$ .
DIV X Y	$OUT = X/Y$ .
CMP X Y	$OUT = b_1b_2b_3b_4b_5b_6b_7b_8$ . $b_i = 0$ if $X_i = Y_i$ . $b_i = 1$ if $X_i \neq Y_i$ .
SHL X Y	$OUT$ is the content of X shifting left Y bits.
SHR X Y	$OUT$ is the content of X shifting right Y bits.
DEF X N	Define X as the number N.

For the "CMP" command, if  $X = 0110$  and  $Y = 1101$ ,  $OUT = 1011$ .

For "SHL" and "SHR" commands, the content of Y can only be one of the following.

Y	Meaning
10000000	(Shift 7 bits)
01000000	(Shift 6 bits)
00100000	(Shift 5 bits)
00010000	(Shift 4 bits)
00001000	(Shift 3 bits)
00000100	(Shift 2 bits)
00000010	(Shift 1 bits)
00000001	(No shift)

For example, if  $X = 00011000$  and  $Y = 00000100$ , the  $OUT$  of "SHL X Y" is 01100000 and the  $OUT$  of "SHR X Y" is 00000110.

For the "DEF" command, N is a number in decimal and X can only be a memory location. "DEF" command is not applicable for assigning values to a register. It is used to assign a value to a memory location. For example, "DEF M1 12" means that memory location M1 will be assigned with a value 12. Therefore,  $M1 = 00001100$ .

**Question 1** Three numbers have been stored in M1, M2 and M3. Write a program segment that can correctly give the output of the formulae below.

$$M4 = M1 + M2 + M3.$$

**Question 2** Three numbers have been stored in M1, M2 and M3. Write a program segment that can correctly give the output of the formulae below.

$$M4 = M1 + M2 - M3.$$

**Question 3** Three numbers have been stored in M1, M2 and M3. Write a program segment that can correctly give the output of the formulae below.

$$M4 = M1 + M2 \times M3.$$

**Question 4** Four numbers have been stored in  $M1$ ,  $M2$ ,  $M3$  and  $M4$ . Write a program segment that can correctly give the output of the formulae below.

$$M5 = (M1 + M2) \times (M3 + M4).$$

**Question 5** Four numbers have been stored in  $M1$ ,  $M2$ ,  $M3$  and  $M4$ . Write a program segment that can correctly give the output of the formulae below.

$$M5 = (M1 - M2) \times (M3 - M4).$$

**Question 6** Three numbers have been stored in  $M1$ ,  $M2$  and  $M3$ . Write a program segment that can correctly give the output of the formulae below.

$$M4 = (2 + M1) \times (M2 + M3).$$

**Question 7** A number (smaller than 7) has been stored in  $M1$ . Without using the command "MUL", write a program segment that can correctly give the output of the formulae below.

$$M2 = 7 \times M1.$$

**Question 8** Two numbers (both are smaller than 7) have been stored in  $M1$  and  $M2$ . Without using the command "MUL", write a program segment that can correctly give the output of the formulae below.

$$M3 = 5 \times M1 + 3 \times M2.$$

**Question 9** Three numbers (all of them are smaller than 4) have been stored in  $M1$ ,  $M2$  and  $M3$ . Without using the command "MUL", write a program segment that can correctly give the output of the formulae below.

$$M4 = 2 \times M1 + 4 \times M2 + 8 \times M3.$$

**Question 10** Three numbers (all of them are smaller than 4) have been stored in  $M1$ ,  $M2$  and  $M3$ . Without using the command "DIV", write a program segment that can correctly give the output of the formulae below.

$$M4 = \frac{M1}{2} + \frac{M2}{4} + \frac{M3}{8}.$$