CS2021 ASSIGNMENT 7 (Due Date: Nov 5, 2021)

Instructions: This assignment consists of twenty questions which are extracted and modified from the 2020 Mid-Term examination paper. You have to answer all of them.

Question 1

With reference to the simple processor as shown in the Appendix, Figure 1, suppose that the registers are preset as $RA = 0$, $RB = 1$, $RZ = 0$, $R1 = R2 = R3 = R4 = 0$. What will be the contents of the registers RA and RB after the following micro-instructions (S1, S2, S3 and S4) have been executed?

S1: $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. The signals to all two-way switches are set to 00.

S2: $S_{14} = 01$. $S_{12} = S_{15} = 10$. The control signals to all connectors are set to 0. The signals to other two-way switches are set to 00.

S3: $S_2 = S_5 = S_9 = 1$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

S4: $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

Answer :

(a) $RA = 0, RB = 0$.

(b) $RA = 0, RB = 1$.

(c) $RA = 1, RB = 0$.

(d) $RA = 1, RB = 1$.

Question 2

With reference to the simple processor as shown in the Appendix, Figure 1, suppose that the registers are preset as $RA = 1$, $RB = 0$, $RZ = 0$, $R1 = R2 = R3 = R4 = 0$. What will be the contents of the registers $R1$ and $R2$ after the following micro-instructions (S1, S2, S3 and S4) have been executed?

S1: $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. The signals to all two-way switches are set to 00.

S2: $S_{14} = 01$. $S_{12} = S_{15} = 10$. The control signals to all connectors are set to 0. The signals to other two-way switches are set to 00.

S3: $S_2 = S_5 = S_9 = 1$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

S4: $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

Answer :

(a) $R1 = 0, R2 = 0$.

(b) $R1 = 0, R2 = 1$.

(c) $R1 = 1, R2 = 0$.

(d) $R1 = 1, R2 = 1$.

Question 3

With reference to the simple processor as shown in the Appendix, Figure 1, suppose that the registers are preset as $RA = 1$, $RB = 0$, $RZ = 0$, $R1 = R2 = R3 = R4 = 0$. What will be the contents of the registers $R3$ and $R4$ after the following micro-instructions (S1, S2, S3 and S4) have been executed?

S1: $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. The signals to all two-way switches are set to 00.

S2: $S_{14} = 01$. $S_{12} = S_{15} = 10$. The control signals to all connectors are set to 0. The signals to other two-way switches are set to 00.

S3: $S_2 = S_5 = S_9 = 1$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

S4: $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

Answer :

(a) $R3 = 0, R4 = 0$.

(b) $R3 = 0, R4 = 1$.

(c) $R3 = 1, R4 = 0$.

(d) $R3 = 1, R4 = 1$.

Question 4

With reference to the simple processor as shown in the Appendix, Figure 1, the following micro-instructions (S1, S2, S3 and S4) have been executed?

S1: $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. The signals to all two-way switches are set to 00.

S2: $S_{14} = 01$. $S_{12} = S_{15} = 10$. The control signals to all connectors are set to 0. The signals to other two-way switches are set to 00.

S3: $S_2 = S_5 = S_9 = 1$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

S4: $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

What of the following instruction have been executed?

Answer:

(a) $R1 = (\neg RA)RB$.

(b) $R2 = (\neg RA)RB$.

(c) $R1 = RA(\neg RB)$.

(d) $R2 = RA(\neg RB)$.

Question 5

With reference to the simple processor as shown in the Appendix, Figure 1, the following micro-instructions (S1, S2, S3 and S4) have been executed?

S1: $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. The signals to all two-way switches are set to 00.

S2: $S_{14} = 01$. $S_{12} = S_{15} = 10$. The control signals to all connectors are set to 0. The signals to other two-way switches are set to 00.

S3: $S_2 = S_5 = S_9 = 1$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

S4: $S_{12} = 10$. $S_{14} = 01$. $S_{15} = 10$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

What of the following instruction have been executed?

Answer :

(a) $R1 = (\neg RA)RB$.

(b) $R2 = (\neg RA)RB$.

(c) $R1 = RA(\neg RB)$.

(d) $R2 = RA(\neg RB)$.

Question 6

While a processor reads (resp. writes) a data from (resp. to) a memory device, it will take some time. The time is called the *memory access time*. In term of memory access time, which of the following device will take the *longest* time for reading (resp. writing) a data from (resp. to) the it?

Answer :

(a) BIOS.

(b) RAM.

(c) Solid state drive (SSD).

(d) Hard drive (i.e. hard disk).

Question 7

While a computer is power off, which of the following devices its content will be lost?

Answer :

(a) BIOS.

(b) RAM.

(c) Solid state drive (SSD).

(d) Hard drive (i.e. hard disk).

Question 8

In a computer, the memory address space is usually larger than the memory space of the solid state drive (SSD) or the hard disk. Some memory addresses are reserved for some particular devices. Which of the following device(s) are assigned with a memory address?

(i) USB port.

(ii) Keyboard.

(iii) Monitor (i.e. panel or video card).

Answer :

(a) (i) and (ii) only.

(b) (ii) and (iii) only.

(c) (i) and (iii) only.

(d) (i), (ii) and (iii).

(e) None of the above options (a), (b), (c) and (d).

Question 9

In a computer, which of the following device(s) has(have) to be connected to the clock circuit for synchronization?

(i) Network card.

(ii) Hard disk.

(iii) RAM.

Answer :

(a) (i) and (ii) only.

(b) (ii) and (iii) only.

(c) (i) and (iii) only.

(d) (i), (ii) and (iii).

(e) None of the above options (a), (b), (c) and (d).

Question 10

If a processor is analogized to a factory, what are the appropriate mappings for (i) a register in a processor and (ii) the main memory?

Answer :

(a) (i) A register could be analogized to a worker in a factory. (ii) The main memory could be analogized to the working space in the factory.

(b) (i) A register could be analogized to a working space in a factory. (ii) The main memory could be analogized to the warehouse for storing final products.

(c) (i) A register could be analogized to a worker in a factory. (ii) The main memory could be analogized to the warehouse for storing final products.

(d) (i) A register could be analogized to a working space in a factory. (ii) The main memory could be analogized to a worker in the factory.

Question 11

Here are four memory locations, $M1$, $M2$, $M3$ and $M4$. Refer to the artificial CPU and its commands, what will be the content of $M4$ if the following commands are executed?

```
DEF M1 3
DEF M2 5
DEF M3 2

MOV IA M1
MOV IB M2
ADD IA IB
MOV IA OUT
MOV IB M3
ADD IA IB
MOV M4 OUT
```

Answer :

(a) 2.

(b) 5.

(c) 8.

(d) 10.

(e) None of the above.

Question 12

Here are four memory locations, $M1$, $M2$, $M3$ and $M4$. Refer to the artificial CPU and its commands, what will be the content of $M4$ if the following commands are executed?

```
DEF M1 3
DEF M2 5
DEF M3 2

MOV IA M1
MOV IB M2
ADD IA IB
MOV IA OUT
MOV IB M3
MUL IA IB
MOV M4 OUT
```

Answer :

(a) 16.

(b) 21.

(c) 25.

(d) 30.

(e) None of the above.

Question 13

Here are four memory locations, $M1$, $M2$, $M3$ and $M4$. Refer to the artificial CPU and its commands, what will be the contents of the registers IB and OUT if the following commands are executed?

```
DEF M1 3
DEF M2 5
DEF M3 2

MOV IA M1
MOV IB M2
ADD IA IB
MOV IA OUT
MOV IB M3
ADD IA IB
MOV M4 OUT
```

Answer :

(a) $IB = 0$ and $OUT = 0$.

(b) $IB = 2$ and $OUT = 0$.

(c) $IB = 0$ and $OUT = 10$.

(d) $IB = 2$ and $OUT = 10$.

(e) None of the above.

Question 14

Refer to the artificial CPU and its commands, what will be the content of $M4$ if the following commands are executed?

```
DEF M1 1
DEF M2 2
DEF M3 5

MOV IA M1
IF IA == 0
   MOV IA M2
   MOV IB M3
   ADD IA IB
   MOV M4 OUT
ELSE
   MOV IA M1
   MOV IB M3
   MUL IA IB
   MOV M4 OUT
ENDIF
```

Answer :

(a) 2.

(b) 7.

(c) 5.

(d) 0.

(e) None of the above.

Question 15

What will be the content of $M4$ if the following program segment is executed?

```
DEF M1 16
DEF M2 22
DEF M3 10

MOV IA M1
MOV IB M2
CMP IA IB
MOV M4 OUT
MOV IA M2
MOV IB M3
CMP IA IB
MOV IA OUT
MOV IB M4
ADD IA IB
MOV M4 OUT
```

Answer :

(a) 28.

(b) 30.

(c) 32.

(d) 34.

(e) None of the above.

Question 16

Find the value of $M3$ after the following program segment has been executed.

```
----------------
DEF M1 13
DEF M2 12

MOV IA M1
SHL IA 00000100
MOV IA OUT
MOV IB M2
ADD IA IB
MOV M3 OUT
----------------
```

Answer :

(a) $M3 = 25$.

(b) $M3 = 38$.

(c) $M3 = 51$.

(d) $M3 = 64$.

(e) None of the above.

Question 17

Refer to the artificial CPU and its commands, what will be the content of $M4$ if the following commands are executed?

```
DEF M1 0
DEF M2 2
DEF M3 5

MOV IA M1
IF IA == 0
   MOV IA M2
   SHL IA 00000100
   MOV IA OUT
   MOV IB M2
   ADD IA IB
   MOV M4 OUT
ELSE
   MOV IA M3
   SHL IA 00000100
   MOV IA OUT
   MOV IB M3
   ADD IA IB
   MOV M4 OUT
ENDIF
```

Answer :

(a) 4.

(b) 6.

(c) 8.

(d) 10.

(e) None of the above.

Question 18

Given that there are five memories M1, M2, M3, M4 and M5. Here is the program segment to instruct the circuit.

```
----------------
MOV IA M1
MOV IB M2
MUL IA IB
MOV IA OUT
MOV IB M3
MUL IA IB
MOV IA OUT
MOV IB M4
SUB IA IB
MOV M5 OUT
----------------
```

Which of the following mathematical equation is identical to the operation of the following program segment?

Answer :

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

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

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

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

(e) None of the above.

Question 19

Given that there are two memories $M1$ and $M2$. Here is the program segment to instruct the circuit.

```
----------------
MOV IA M1
MOV IB M1
SHL IA 00000010
MOV IA OUT
SHL IB 00000100
MOV IB OUT
ADD IA IB
MOV IB OUT
MOV IA M1
ADD IA IB
MOV M2 OUT
----------------
```

Which of the following mathematical equation is identical to the operation of the following program segment?

Answer :

(a) $M2 = 3 \times M1$.

(b) $M2 = 5 \times M1$.

(c) $M2 = 7 \times M1$.

(d) $M2 = 9 \times M1$.

(e) None of the above.

Question 20

Given that there are four memory slots $M1$, $M2$, $M3$ and $M4$. Here is the program segment to instruct the circuit.

```
----------------
MOV IA M1
MOV IB M2
SHL IA 00000010
MOV IA OUT
SHL IB 00000100
MOV IB OUT
ADD IA IB
MOV IB OUT
MOV IA M3
ADD IA IB
MOV M4 OUT
----------------
```

Which of the following mathematical equation is identical to the operation of the following program segment?

Answer :

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

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

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

(d) $M4 = 7 \times (M1 + M2 + M3)$.

(e) None of the above.

APPENDIX

In this appendix, it includes the information about a simple processor, an artificial CPU, the source codes of five programs and a useful table. Please read them carefully!

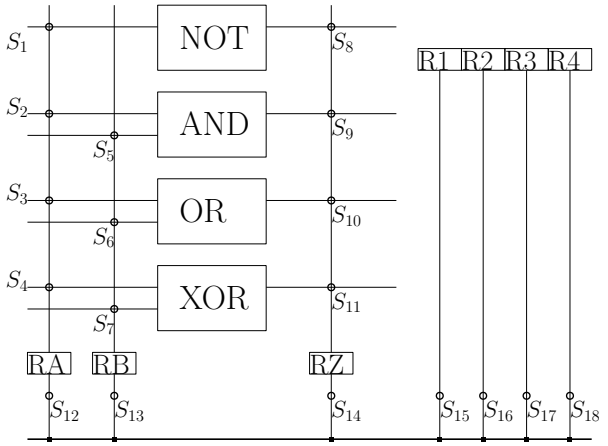
A. Simple Processor

A simple processor, with a sector of four logic gates and a sector of four registers, shown in Figure 1. Each register is associated with a two-way switch. The signals to be fed to the switch and the corresponding actions are depicted in the following table.

S_i	Action
00	Disconnect.
01	Read from register.
10	Write to register.

For each connector, its control signal is either '0' (for disconnection) and '1' (for connection).

$$\text{Connection} = \begin{cases} \text{Connect} & \text{if } S_i = 1, \\ \text{Disconnect} & \text{if } S_i = 0. \end{cases}$$



Two-Way Switches: Disconnected (00); Down (01), Up (10).

$(S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18})$

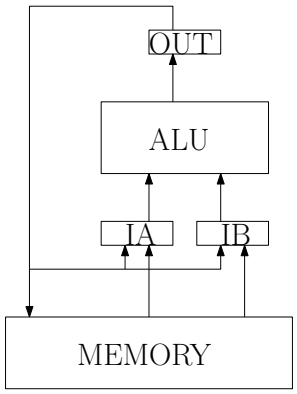
Connectors: Disconnected (0), Connected (1).

$(S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11})$

Figure 1: A processor with four logic gates. Switches S_1 to S_{11} are simple switches (i.e. connectors). S_{12} to S_{18} are two-way switches.

B. Artificial CPU

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 *8-bit 2's compliment integer format.*



Eleven commands (MOV, ADD, SUB, MUL, DIV, CMP, SHL, SHR, DEF, MSK and IF) are provided for instructing the above circuit. The syntax and the descriptions of these commands are depicted in Table 1.

Table 1: Commands for using the CPU.

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.
MSK X M	Mask the value of X by M.
IF ELSE	Condition statement.

C. Notes on CPU Commands

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

2. 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

$$X = 00011000, Y = 00000100,$$

   the OUT of "SHL X Y" is 01100000 and the OUT of "SHR X Y" is 00000110.

3. For the "DEF" command, N must be a number in *decimal* form. 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, $M1 = 00001100$.

4. For the "MSK" command, it is used for masking a register (either IA or IB) by the mask M (in binary). The mask must be 8 bits long.

   Suppose that the content of IA and M are defined as follows :

$$IA = 01001001, M = 11110000.$$

   Then, the output OUT will be "01000000". The last four bits are masked. Here is an example.

```
------------------------
DEF M1 45
MOV IA M1
MSK IA 00001111
MOV M2 OUT
------------------------
```

   Initially, $M1$ is assigned with value 45. In binary form, the content reads "00101101". Thus, the output OUT is "00001101".

5. The "IF-ELSE" command is an advanced level command. It is for conditional statement. Once it is executed, the CPU will performs multiple steps in order to make it works. You do not need to know the detail how it works. In term of its usage, it is simple. Here is an example.

```
------------------------
DEF M1 1
DEF M2 2
DEF M3 1

MOV IA M1
IF IA == 0
   MOV IA M2
   MOV IB M3
   ADD IA IB
   MOV M4 OUT
ELSE
   MOV IA M1
   MOV IB M2
   ADD IA IB
   MOV M4 OUT
ENDIF
------------------------
```

   Command "IF" checks if the content of IA is identical to "0". If it is, it will perform $M2+M3$ and output the result to $M4$. Otherwise, it will perform $M1 + M2$ and output the result to $M4$.

```
------------------------
DEF M1 1
DEF M2 2
DEF M3 1

MOV IA M1
IF IA == 0
   MOV IA M2
   MOV IB M3
   ADD IA IB
   MOV M4 OUT
ENDIF
------------------------
```

   In this example, the CPU performs $M2 + M3$ only if IA is zero. Otherwise, it performs nothing.

6. For the "IF-ELSE" command, the following conditions are allowed for you to define. Here NUM must be stated in decimal form but not in binary.

```
------------------------
IA == NUM
IA > NUM
IA >= NUM
IA < NUM
IA <= NUM
------------------------
```

Step	IA	IB	OUT	$M1$	$M2$	$M3$	$M4$
0	00000000	00000000	00000000	00000000	00000000	00000000	00000000
1	00000000	00000000	00000000	00001000	00000000	00000000	00000000
2	00000000	00000000	00000000	00001000	00000101	00000000	00000000
3	00000000	00000000	00000000	00001000	00000101	00000010	00000000
4	00001000	00000000	00000000	00001000	00000101	00000010	00000000
5	00001000	00000101	00000000	00001000	00000101	00000010	00000000
6	00001000	00000101	00001101	00001000	00000101	00000010	00000000
7	00001101	00000101	00001101	00001000	00000101	00000010	00000000
8	00001101	00000010	00001101	00001000	00000101	00000010	00000000
9	00001101	00000010	00011010	00001000	00000101	00000010	00000000
10	00001101	00000010	00011010	00001000	00000101	00000010	00011010

Figure 2: Useful table for showing the contents in the registers and the memory spaces.

D. Useful Table

Owing to answer the last ten questions, you could use the table as shown in Figure 2 to fill up the contents in the registers (IA, IB and OUT) and the memory spaces ($M1$, $M2$, $\cdots$, $M16$). Let say, the following program is to be executed. For convenience, the step number is added on the beginning of each line of code.

```
-----------------------
S1: DEF M1 8
S2: DEF M2 5
S3: DEF M3 2

S4: MOV IA M1
S5: MOV IB M2
S6: ADD IA IB
S7: MOV IA OUT
S8: MOV IB M3
S9: MUL IA IB
S10: MOV M4 OUT
-----------------------
```

Before running the above program, i.e. the Step 0, it is assumed that the contents in the registers and the memory spaces are set to 00000000.

After the program has been executed, as shown in Figure 2, the contents of the registers and the memory spaces are as follows :

$$IA = 13, IB = 2, OUT = 26.$$

$$M1 = 4, M2 = 5, M3 = 2, M4 = 26.$$

If another program is going to be executed afterward, the contents in the registers and the memory spaces will be set to 00000000 again.