Introduction to Computer Science: Mid-Term Exam

November 6, 2020. 9:30 - 11:00

Name: _____

Student ID: _____

Instructions: This paper consists of 50 multiple choice questions. You need to answer all of them. For each question, there is only ONE correct answer. Each carries 2 marks. There is no penalty score if the answer is incorrect.

$$\text{Score} = \begin{cases} +2 & \text{if the answer is correct,} \\ 0 & \text{if there is no answer,} \\ 0 & \text{if the answer is incorrect.} \end{cases}$$

Please circle your answer, or write down your answer on the left of the question, either by using a blue or black ball pen. Dictionary and calculator are allowed.

Please do not take away this paper. This paper has to be returned for marking.

SECTION A : Logical Questions

Instructions for Question 1 to Question 10: The questions below are logical questions. In each question, two statements X and Y are given. You have to identify from the following options what is their relation.

(a) Both statements are not true.

(b) Statement X is true. Statement Y is not true.

(c) Statement X is not true. Statement Y is true.

(d) Statement X is true. Statement Y is true. Statement X and Statement Y have no logical implication.

(e) Statement X is true. Statement Y is true. Statement X is a cause of Statement Y.

(f) Statement X is true. Statement Y is true. Statement Y is a cause of Statement X.

(g) Statement X is true. Statement Y is true. Statement Y is a cause of Statement X. Statement X is also the cause of the Statement Y. That is to say, Statement X is true if and only if Statement Y is true.

Question 1

X: UK made the world first commercial computer in the mid-twenty century.

Y: In UK, Babbage built a mechanical computer called the difference machine in the 19th century.

Question 2

X: Alan Turing built the first electronic computer in US during the World War II.

Y: Alan Turing used the electronic computer made in US to break the encryption code which was used by the German army to encode/decode radio messages during the World War II.

Question 3

X: Mouse was invented by a group of engineers in Xerox.

Y: Steve Job made use of mouse to develop graphical user interface for controlling the operating system of a Mackintosh personal computer.

Question 4

X: An App developer has to pay commission to Apple whenever his/her App has been purchased by a buyer over the Apple App Store.

Y: An iOS App developer is a customer of Apple.

Question 5

X: The number of binary bits to represent an English character is eight.

Y: The number of binary bits to represent a Japanese character is sixteen.

Question 6

X: The range of numbers in 16-bit floating point format is much larger than the range of numbers in 16-bit sign-magnitude fixed point format. Here, the range of numbers refers to the difference between the

maximum and the minimum numbers which can be represented,

$$\text{RANGE} = \text{MAX NUM} - \text{MIN NUM}.$$

Y: The decimal number 0.1 can be represented in both the 16-bit floating point format and 16-bit sign-magnitude fixed point format.

Question 7

X: Every digital logic circuit can be implemented only by NAND gates.

Y: Every logic gate can be implemented by NAND gates.

Question 8

X: In a computer, the CPU can read (resp. write) data from (resp. to) a network card.

Y: In a computer, the network card is assigned with a memory address.

Question 9

X: BIOS is a volatile memory device.

Y: Once a computer is power on, the CPU will automatically read the first instruction from the BIOS.

Question 10

X: The number of micro-instructions to be executed in one second depends on the number of clock cycle a CPU can perform.

Y: The efficiency of a CPU is determined only by the number of clock cycle a CPU can perform.

SECTION B : Regular Questions

Question 11

In ancient China, which of the following tool was used for computing?

Answer:

(a) Balloons

(b) Abacus

(c) Candles

(d) Sticks

Question 12

Which of the following company released the first commercial computer in US?

Answer:

(a) J. Lyon and Company

(b) LEO Technology

(c) Remington Rand

(d) ENIAC Corporation

Question 13

Which of the following pioneers introducing a conceptual model of computer in the earlier twenty century?

(i) Alan Turing.

(ii) John Ambrose Fleming.

(ii) John von Neumann.

Answer:

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

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

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

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

Question 14

Which of the following statements are true?

(i) Without electricity, no information system can be used.

(ii) Without computer, no information system can be built.

(iii) The functional requirements of an information system are determined by the business operations of an organization.

(iv) Information technology is a collection of technologies which can be applied in building an information system.

Answer:

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

(b) (i) and (iii) only.

(c) (i) and (iv) only.

(d) (ii) and (iii) only.

(e) (ii) and (iv) only.

(f) (iii) and (iv) only.

Question 15

Which of the following item(s) has(have) a computer installed?

(i) Aeroplane

(ii) Spaceship

(iii) Satellite

Answer:

(a) None of them.

(b) (i) only.

(c) (ii) only.

(d) (iii) only.

(e) (i) and (ii) only.

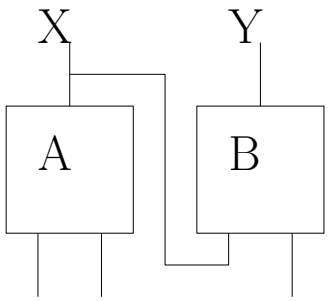
(f) (ii) and (iii) only.

(g) (i) and (iii) only.

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

Diagram for Questions 16-25

It is a circuit consisting of two logic gates.



Question 16

What are the output values X and Y if A is an XOR gate, B is an AND gate and the input (from left to right) is 101.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 17

What are the output values X and Y if A is an OR gate, B is an OR gate and the input (from left to right) is 111.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 18

What are the output values X and Y if A is an AND gate, B is an XOR gate and the input (from left to right) is 101.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 19

What are the output values X and Y if A is an OR gate, B is an NAND gate and the input (from left to right) is 011.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 20

What are the output values X and Y if A is an NAND gate and B is an NAND gate and the input (from left to right) is 010.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 21

What are the output values X and Y if A is an OR gate, B is an NAND gate and the input (from left to right) is $x11$. Here x is an unknown.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 22

What are the output values X and Y if A is an NAND gate and B is an NAND gate and the input (from left to right) is $0x0$. Here x is an unknown.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 23

What are the output values X and Y if A is an AND gate, B is an XOR gate and the input (from left to right) is $x01$. Here x is an unknown.

Answer :

(a) $X = 0, Y = 0$.

(b) $X = 0, Y = 1$.

(c) $X = 1, Y = 0$.

(d) $X = 1, Y = 1$.

Question 24

If the input (from left to right) is $1x1$, and the output $X = 1$ and $Y = 1$, ('x' means that the second input is unknown), which of the following combinations of gates will give this output?

(i) A is a OR gate and B is a OR gate.

(ii) A is a OR gate and B is an AND gate.

(iii) A is an AND gate and B is a OR gate.

Answer :

(a) (i) & (ii)

(b) (ii) & (iii)

(c) (i) & (iii)

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

Question 25

If the input (from left to right) is $1x1$, and the output $X = 1$ and $Y = 0$, ('x' means that the second input is unknown), which of the following combinations of gates will give this output?

(i) A is a OR gate and B is a XOR gate.

(ii) A is a OR gate and B is an NAND gate.

(iii) A is an NAND gate and B is a XOR gate.

Answer :

(a) (i) & (ii)

(b) (ii) & (iii)

(c) (i) & (iii)

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

Question 26

With reference to the simple processor as shown in the Appendix, Figure 1, which of the following micro-instruction designs will execute the following instruction without error?

$$RZ = RA + RB,$$

where + is the OR operation.

(i) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{12} = \cdots = S_{18} = 00$.

(ii) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{12} = 01$. $S_{13} = \cdots = S_{18} = 00$.

(iii) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{12} = 01$. $S_{14} = 10$. The signals to other two-way switches are set to 00.

Answer :

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

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

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

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

Question 27

With reference to the simple processor as shown in the Appendix, Figure 1, which of the following micro-instruction designs will execute the following instruction without error?

$$R1 = RA + RB,$$

where + is the OR operation.

(i) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{12} = \cdots = S_{18} = 00$.

(ii) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{14} = 01$. $S_{15} = 10$. The signals to other two-way switches are set to 00.

(iii) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{14} = 10$. $S_{15} = 01$. The signals to other two-way switches are set to 00.

Answer :

(a) (i) only.

(b) (ii) only.

(c) (iii) only.

(d) None of them.

Question 28

With reference to the simple processor as shown in the Appendix, Figure 1, which of the following micro-instruction designs will execute the following instruction without error?

$$R1 = RA + RB,$$

where + is the OR operation.

(i) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{14} = 10$. $S_{15} = 01$. The signals to other two-way switches are set to 00.

(ii) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{14} = 01$. $S_{15} = 10$. The signals to other two-way switches are set to 00.

(iii) $S_3 = S_6 = S_{10} = 1$. The control signals to other connectors are set to 0. $S_{14} = 01$. $S_{15} = S_{16} = 10$. The signals to other two-way switches are set to 00.

Answer :

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

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

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

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

Question 29

With reference to the simple processor as shown in the Appendix, Figure 1, which of the following micro-instruction designs will execute the following instruction without error?

$$R1 = R2 = \neg RA,$$

where $\neg$ is the NOT operation.

(i) $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. $S_{14} = 01$. $S_{15} = S_{16} = 10$. The signals to other two-way switches are set to 00.

(ii) $S_1 = S_9 = 1$. The control signals to other connectors are set to 0. $S_{14} = S_{15} = S_{16} = 01$. The signals to other two-way switches are set to 00.

(iii) $S_1 = S_8 = 1$. The control signals to other connectors are set to 0. $S_{14} = S_{15} = 01$. $S_{16} = 10$. The signals to other two-way switches are set to 00.

Answer :

(a) (i) only.

(b) (ii) only.

(c) (iii) only.

(d) None of them.

Question 30

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 RZ after the following micro-instructions (S1, S2 and S3) 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: $S_2 = S_5 = S_9 = 1$. $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. The control signals to other connectors are set to 0. The signals to other two-way switches are set to 00.

Answer :

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

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

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

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

Question 31

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 and S3) 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: $S_2 = S_5 = S_9 = 1$. $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. 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 32

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 and S3) 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: $S_2 = S_5 = S_9 = 1$. $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. 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 33

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 and S3) 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: $S_2 = S_5 = S_9 = 1$. $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. 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 34

With reference to the simple processor as shown in the Appendix, Figure 1, the following micro-instructions (S1, S2 and S3) 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: $S_2 = S_5 = S_9 = 1$. $S_{12} = 10$. $S_{14} = 01$. $S_{16} = 10$. 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 35

With reference to the simple processor as shown in the Appendix, Figure 1, the following micro-instructions (S1, S2 and S3) 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: $S_2 = S_5 = S_9 = 1$. $S_{12} = 10$. $S_{14} = 01$. $S_{15} = 10$. 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 36

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 37

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 38

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).

Question 39

In a computer, which of the following devices have to be connected to the clock circuit for the clock signals?

(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).

Question 40

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

Answer :

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

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

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

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

Question 41

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 42

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 43

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 44

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 IA M2
   MOV IB M3
   ADD IA IB
   MOV M4 OUT
ELSE
   MOV IA M1
   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 45

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
CMP IA IB
MOV M4 OUT
MOV IA M2
MOV IB M3
CMP IA IB
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 46

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 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 47

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 48

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 49

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
SHL IB 00000100
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 50

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
SHL IB 00000100
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 and the source codes of five programs. Please read them carefully!

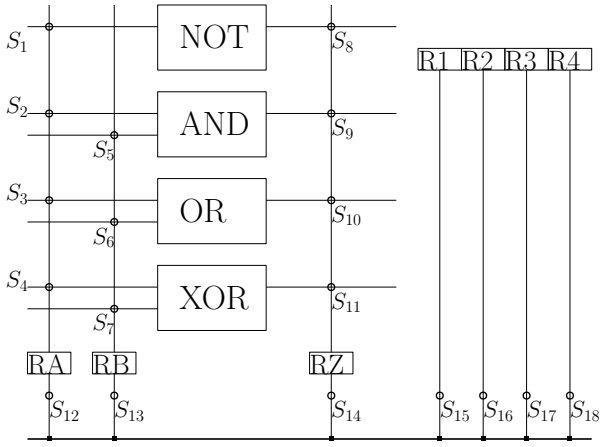
A. Simple Processor

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).

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

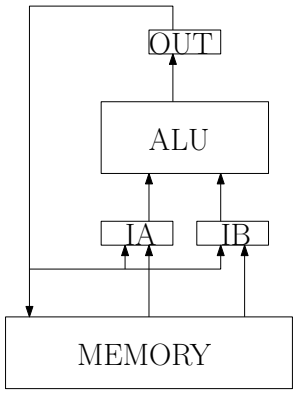
Connectors: Disconnected (0), Connected (1).

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

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 *2's compliment* 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
   ADD IB M2
   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
------------------------
```