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الجامعة العربية المفتوحة
Arab Open University
Faculty of Computer Studies

T103/TM103

Computer Organization and Architecture

Final Examination

Solution

Fall Semester 2023/2024

Date: ?? /??/2024

Number of Exam Pages: (6) (including this cover sheet)
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Time Allowed: (2) Hours

Instructions:

- Total Marks: **100**
- This exam consists of **3** parts.
- **ALL questions** must be answered in the External Answer booklet.
- Be sure you write your **name and ID** on the External Answer booklet.
- **Programmable Calculators** are **not** allowed.

Part I: Choose the most correct answer (20 marks)

This part consists of **10 questions** carrying a **weight of two marks each**.

You should answer **ALL** the following:

1. An indirect addressing mode means that:
 - a) The value is implicitly stated in the instruction.
 - b) The address of the operand is explicitly stated in the instruction.
 - c) The address of the operand is to be found in the ALU.
 - d) **None of the choices.**
2. For a 3-input NOR gate, the output will be 1 only if:
 - a) Any of the inputs is 0.
 - b) **All inputs are 0.**
 - c) All inputs are 1.
 - d) All inputs are equal.
3. The unsigned 8-bit binary equivalent to the Hexadecimal number **E5** is:
 - a) 11110101
 - b) 11100100.
 - c) **11100101**
 - d) 000011100011
4. Which of the following is not a sequential circuit?
 - a) Decoder
 - b) Counter
 - c) Multiplexer
 - d) **Both a and c.**
5. If a carry-out of the leftmost bit occurs in an addition of two signed numbers using 1's complement, then:
 - a) It will be discarded.
 - b) We have an erroneous result.
 - c) **It will be added to the sum.**
 - d) None of the above.
6. A flip flop that is usually used to build registers is called:
 - a) **D Flip Flop.**
 - b) JK Flip Flop
 - c) RS Flip Flop
 - d) T Flip Flop.
7. Which of the following is true about Static RAM?
 - a) Needs refreshing.
 - b) **Used as Cache memory.**
 - c) Very cheap compared to DRAM.
 - d) Both a and b.
8. If we have a **16K * 16-bit** memory module (Byte addressable), then the needed number of address lines is:
 - a) 16.
 - b) 19
 - c) **15**
 - d) 21.
9. A CPU component responsible for fetching the next program instruction from memory is:
 - a) Bus.
 - b) Register.
 - c) **Control Unit.**
 - d) Arithmetic Logic Unit
10. The Cache memory is usually:
 - a) Greater and faster than the main memory.
 - b) Greater and slower than the main memory.
 - c) Smaller and slower than the main memory.
 - d) **Smaller and faster than the main memory.**

Part II: Short essay questions**(30 marks)**

This part consists of five **questions** carrying a **WEIGHT OF 6 marks each**.

You should attempt all questions.

Remark for questions in Part 2:

All the answers below for the questions are considered ideal answers to be considered in correction. However, the tutor should expect student's answers to be provided in a different style and format. Kindly consider these answers and allow for partial marks to be awarded accordingly.

1. List the three **simplest gates/Operators** used in logical design and draw their truth tables.

Answer: (6 marks: 2 marks for each)

The three simplest gates are the AND, OR, and NOT gates.

X AND Y			X OR Y			NOT X	
X	Y	XY	X	Y	X+Y	X	X'
0	0	0	0	0	0	0	1
0	1	0	0	1	1	1	0
1	0	0	1	0	1	0	1
1	1	1	1	1	1	1	0

2. Answer the following questions:

- In the computer architecture context, what is feedback?
- How are sequential circuits different from combinational circuits?

Answer: (6 marks: 2 +4)

- Feedback simply means that the output of a circuit is fed back as an input to the same circuit.
- A combinational circuit is a device whose output is always based entirely on the given inputs, while a sequential circuit is a logic device whose output is defined in term of its current inputs in addition to its previous output.

3. Using MARIE instruction set, find the equivalent assembly codes of the following binary instructions.

- 1001 0010 1010 0000.**
- 0010 1100 0010 0101.**

Answer: (6 marks: 3 marks for each instruction)

- Jump 2A0
- Store C25

4. What do the following acronyms stand for: EEPROM, USB, DRAM?

Answer: (6 marks: 2 marks for each)

- EEPROM: Electrically Erasable Programmable ROM
- USB: Universal Serial Bus.
- DRAM: Dynamic Random Access Memory.

5. Given the below K-Map diagram, answer the following questions:

- a- Find the Sum of Product form of the Function F.
 b- Deduce the simplified form of the function F.

	b'c'	b'c	bc	bc'
a'	1	0	0	1
a	0	0	1	1

Answer: (6 Marks: 3+3)

a- $F = a'b'c' + a'bc' + abc' + abc$

b- $F_{\text{simp}} = a'c' + ab$ (deduct 1 mark for any redundant term)

Part III: Numerical problems

(50 marks)

This part consists of **four questions** carrying a weight of **50 marks**.

You should **answer all questions**.

1. Given $F(x,y,z) = \bar{y} \cdot \bar{z} + y(\bar{x} + \bar{z})$.

[12 marks]

- a) Complete the truth table below of F(x,y,z).
 b) Draw the K-map of F, and deduce the simplified result of F.

x	y	z	x'	y'	z'	y'z'	x'+z'	y(x'+z')	F
0	0	0							
0	0	1							
0	1	0							
0	1	1							
1	0	0							
1	0	1							
1	1	0							
1	1	1							

Answer :

a) (6 marks: 4 marks for the intermediate results; 2 marks for the output)

x	y	z	x'	y'	z'	y'z'	x'+z'	y(x'+z')	F
0	0	0	1	1	1	1	1	0	1
0	0	1	1	1	0	0	1	0	0
0	1	0	1	0	1	0	1	1	1
0	1	1	1	0	0	0	1	1	1
1	0	0	0	1	1	1	1	0	1
1	0	1	0	1	0	0	0	0	0
1	1	0	0	0	1	0	1	1	1
1	1	1	0	0	0	0	0	0	0

b) (6 marks: 4 marks for the K-map, 2 marks for the simplified F)

	$y'z'$	$y'z$	yz	yz'
x'	1	0	1	1
x	1	0	0	1

$$F = \bar{z} + \bar{x}y$$

2. Answer the following questions:

[12 marks]

- Find the values of (-73) and (-56) in 8-bits binary representation using **C2** representation.
- Find the sum of (-73) and (-56) in 8-bits binary representation using **C2** representation.
- What can you say about the result? Discuss.

Answer: (10 marks)

a) (5 marks)

$$-73 = 10110111(\text{C2}) \quad (2.5 \text{ marks})$$

$$-56 = 11001000(\text{C2}) \quad (2.5 \text{ marks})$$

b) (4 marks: 3 marks for the addition, showing that the carry-out of the 8th bit isn't added; 1 mark for the final result)

$$\begin{array}{r} 10110111 \\ + 11001000 \\ \hline \end{array}$$

$$01111111 \quad (\text{which is } +127)$$

c) The result is incorrect as (-128) is the sum of the two negative numbers. (3 marks)

3. Given the memory and register R1 containing the values below, you are asked to answer the following questions, considering that the initial value of the AC is 200 in each part:

[12 marks]

- What will be the value in AC after executing the instruction **Add 200** using **immediate** addressing mode?
- What will be the value in AC after executing the instruction **Load 500** using **indexed** addressing mode?
- Which of the following will be affected after executing the instruction **Store 300** using **indirect** addressing mode: Memory location or AC? Indicate the place/location that will be affected and the value that will be in it.

Note that for each part the initial value of AC is 200

100	200
...	
200	400
...	
300	600
...	
400	300
...	
500	100
...	
600	400
...	
700	300
...	
1000	300

R1
200

Answer: (12 marks: 4 marks for each correct answer)

- a. 400
- b. 300
- c. Memory location 600, and the value in it will be 200.

4. Assume that we have the following **16-way** set associative cache representation:

16-way set associative		
10	11	6

Answer the following questions based on the above data:

[14 marks]

- a- What is the number of words per cache block?
- b- What is the size of the main memory?
- c- What is the number of sets?
- d- Based on your answer in part c, what is the number of blocks in the cache memory?

Draw the format of the memory address as seen by the cache, showing the fields as well as their sizes, for the following scheme:

e- Direct Mapped Cache.

Answer:

- a- The number of words is 2^6 (64) words per cache block. **(2 marks)**
- b- The size of the main memory is 2^{27} (128 M) words. **(2 marks)**
- c- The number of sets is 2^{11} (2048). **(2 marks)**
- d- The number of blocks in the cache memory is 2^{15} (32K) **(2 marks)**
- e- Each address has 27 bits, and there are **6** in the tag field, **15** in the set field and **6** in the word field. **(6 marks: 2 marks for each field)**

6	15	6
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End of Questions