Cairo University, Faculty of Computers
and Artificial Intelligence

FACULTY OF COMPUTERS AND ARTIFICIAL INTELLIGENCE, CAIRO UNIVERSITY

CS111: Fundamentals of CS
Fall 2022 / 2023

Sheet 3 – Version 4.0

Course Professors:

Dr. Mohammad El-Ramly

Revision History

Version 1.0	By Dr. Mohammad El-Ramly	16 Nov. 2016
	Dr. Nouh Sabry	
	Eng. Huda Mahgoub	
	Eng. Hassan Mourad	
	Eng. Menna Youssef	
	Eng. Shimaa Elshazly	
Version 2.0	By Dr. Mohammad El-Ramly	24 Nov. 2017
Version 3.0	By Dr. Eman Hossny	22 Nov. 2018
Version 4.0	By Dr. Mohammad El-Ramly	04 Dec. 2021

CS111: Fundamentals of CS
Sheet 3 – Version 4.0

Cairo University, Faculty of Computers
and Artificial Intelligence

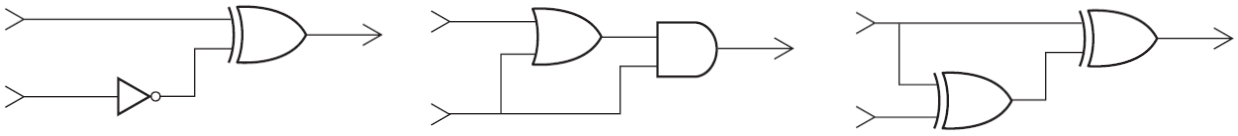
Objectives

By solving this entire sheet completely, you will achieve the following goals:

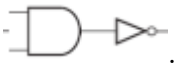
1- Train on representing images, audio and video inside computers and data storage.
2- Train on problem solving problems on machine language and data manipulation.
3- Train on using Python for problem solving using files, dictionaries, etc.

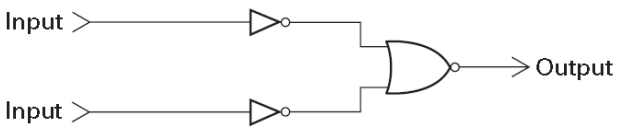
1. Bits and Their Storage

1. Determine the output of each of the following circuits, assuming that the upper input is 1 and the lower input is 0. What would be the output when the upper input is 0 and the lower is 1?

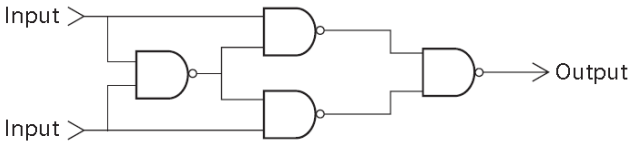


a. b. c.

2. What Boolean operation do the following circuits compute? Show the steps of your solution. Note that  is a NAND gate which is NOT AND, i.e., AND gate followed by NOT gate like  .



a.



b.

3. Build and XOR gate using a circuit of other gates. (Different from the ones in question 2 above)

2. Main Memory

4. What is the value of the least significant bit (LSB) and most significant bit (MSB) in the following numbers?

a. CD (hexa) b. 67 (hexa) c. 11001011 (binary) d. 10101010 (binary)

5. The following table represents the addresses and contents (using hexadecimal notation) of some cells in a machine's main memory. Starting with this memory arrangement, follow the sequence of instructions and record the final contents of each of these memory cells:

Step 1. Move the contents of the cell whose address is 03 to the cell at address 00.
Step 2. Move the value 01 into the cell at address 02.
Step 3. Move the value stored at address 01into the cell at address 03.

Address	Contents
00	AB
01	53
02	D6
03	02

6. How many cells can be in a computer's main memory if each cell's address can be represented by two hexadecimal digits? What if four hexadecimal digits are used?

CS111: Fundamentals of CS
Sheet 3 – Version 4.0

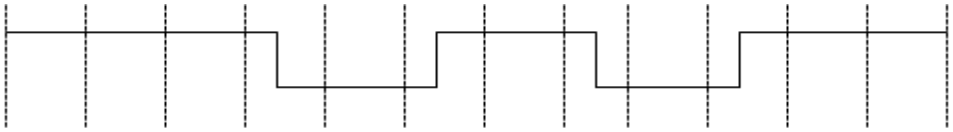
Cairo University, Faculty of Computers
and Artificial Intelligence

3. Mass Storage

7. Assume the following mass storage devices:
   - Hard disks CDs DVDs Blu Ray Flash drives Solid-state disks (SDD)

   a. Which of these devices does not include mechanical parts?
   b. Which of these devices uses laser beams to create pits on the surface of plastic disc coated with aluminium?
   c. Which of these storage devices have the biggest storage capacity?
   d. Which of these devices store data in one long spiral track?
   e. Which devices works by magnetizing its surface using a read/write head?
   f. Which devices support direct access of data? (What does direct access mean?)

8. Assume the following sequence of pits and lands on the surface of a CD disc. Write the corresponding sequence of ones and zeros.



9. Suppose a digital camera has an SD with storage capacity of 16GB. How many bitmap photos could be stored in the camera if each consisted of 1024 pixels per row and 1024 pixels per column and the photos have true colours stored without any encoding or compression?

10. Suppose a picture is represented on a display screen by a rectangular array containing 1024 columns and 768 rows of pixels. If for each pixel, 8 bits are required to encode the colour and another 8 bits to encode the intensity, how many byte-size memory cells are required to hold the entire picture?

11. How many bytes of storage space would be required to store a 400-page novel in which each page contains 3500 characters if ASCII were used? How many bytes would be required if Unicode (UTF-16) was used?

12. Suppose that we have a hard drive with the following characteristics. It has 1,000 cylinders, 100 tracks per cylinder, 600 sectors per track, and 5,100 bytes per sector. The hard drive spins at 5,400 rpm (rotations per minute) and has an average seek time of 11 ms.
    a. Calculate the capacity of the hard drive.
    b. Calculate the time required to complete one full cycle by the disk.
    c. Calculate the average latency of the hard drive.
    d. Calculate the time required to transfer one sector.
    e. Give the TOTAL time that it takes to transfer 20,400 bytes.

    Remember
    (1) seek time is the time required to move read / write heads from one track to another)
    (2) rotation delay or latency time is half the time required for the disk to make a complete rotation
    (3) access time I the sum of seek time and rotation delay; and
    (4) transfer rate is the rate at which data can be transferred to or from the disk.

13. Which of the following order of hard disk components is ascending (from the smallest to the largest units)?

a) Sector, Track, Cylinder	b) Track, Sector, Cylinder	c) Sector, Cylinder, Track	d)Cylinder, Sector, Track

14. 10^{18} bytes is called ……
    (a) terabyte (b) petabyte (c) exabyte (d) zettabyte

15. How long is the latency time (average rotational delay) of a hard disk spinning at 3600 rpm (revolutions per minutes)?

    (a) 0.01667 (b) 0.0002778 (c) 0.008333 sec (d) 0.0005556

16. If a report consists of 20 pages, each containing 40 lines of 100 symbols each (counting each space as a symbol), was to be encoded using Unicode-16, how many bytes of storage space would be required?

    (a) 160,000 (b) 80,000 (c) 4,000 (d) 2,000

17. Two disadvantages of solid state disks compared to magnetic disks are ……. and ……

4. Image Representation

18. Solve the quiz on image representation at the link below. Study before you do it and write your email accurately to get the results of your evaluation. Link https://bit.ly/2Cw27Gu or https://docs.google.com/forms/d/e/1FAIpQLSdGDrBacRQEgBwO-8X_ZkcZxhfBMWyPCrjjJUgUn6WS5ngJEw/viewform?fbzx=-5542181793728683000

19. **Images Representation.** Assume that you have the given picture and its dimensions are 1024 pixels per row and 1024 pixels per column. What is the size of the storage required to store this picture in each of the **three** given versions: pure black and white, grey scale and colored? (assume grey scale version supports 256 shades of grey and colored one is stored in raw bitmap format using RGB representation). **Write your calculations.**

(a) (b) (c)

Figure 1 Different version of the same image; black and white (a), grey-level (b), and colour (c).

20. **Image Formats**

    a. What are the **advantages** of representing **images** via **geometric** (vector) structures as opposed to bit maps?

    b. **Why** would GIF be better than JPEG when encoding color cartoons?

    c. **What** characteristic of the human eye does JPEG's baseline standard exploit؟

    d. Suppose you were part of a team designing a spacecraft that will travel to other planets and send back photographs. **Would it be** a good idea to compress the photographs using GIF or JPEG's baseline standard to reduce the resources required to store and transmit the images?

21. **Bitmap Images**

Read this article and answer the following question http://paulbourke.net/dataformats/bitmaps/

a. Explain what is meant by **resolution** for bitmap images.
b. How much storage space is needed to store a 600 x 800 pixels picture if color depth is (1) 1 bit, (2) 8 bits and (3) 24 bits?
c. The importance and advantages of PNG bitmap image format.
d. The difference between lossy and lossless compression methods.

5. Machine Language

For these problems assume a virtual computer machine that has 16 general-purpose registers numbered 0 through F (in hexadecimal). Each register is one byte (eight bits) long. For identifying registers within instructions, each register is assigned the unique four-bit pattern that represents its register number. Thus register 0 is identified by 0000 (hexadecimal 0), and register 4 is identified by 0100 (hexadecimal 4).

There are 256 cells in the machine's main memory. Each cell is assigned a unique address consisting of an integer in the range of 0 to 255. An address can therefore be represented by a pattern of eight bits ranging from 00000000 to 11111111 (hexadecimal values from 00 to FF).

Floating-point values are assumed to be stored in an eight-bit format discussed in Section 1.7 and summarized in Figure 1.24 in the book.

Each machine instruction is two bytes long. The first 4 bits are the op-code; the last 12 bits make up the operand field. The table that follows lists the instructions in hexadecimal notation together with a short description of each. The letters R, S, and T represent register numbers in hexadecimal. Letters X and Y represent numbers or bit patterns in hexadecimal.

For the next three questions use the machine language given at the end of the sheet.

Try all the programs you write on the simulator and verify that it produces the expected results.
https://github.com/Megadardery/machine-language/releases

```
Address Instruction
 20      2000
 22      11A0
 24      2280
 26      8221
 28      B230
 2A      234E // Put N ASCII in R3
 2C      3300 // write to screen
 2E      B034
 30      2350
 32      3300
 34      C000
```

22. What is the purpose or function of the machine language program on the side? What does it do and how does it do it?
23. Assume a number is stored in memory cell A0h as a floating point num using the book's representation. Write a program that converts the number to its absolute value and stores it in the same memory cell.
24. Assume two integer numbers are stored in in the memory cell numbers 80 h and 81 h in two's complement format. Write a program that checks if adding these two numbers will cause an overflow or not. (Hint: Extract the sign bits and use XOR to know if they are similar or different. Overflow occurs if two numbers of the same sign are added and the result has a different sign)

CS111: Fundamentals of CS
Sheet 3 – Version 4.0

Cairo University, Faculty of Computers and Artificial Intelligence

25. Decode each of the following instructions that were encoded using the language description table.

    A. 4034 _____

    B. 8023 _____

    C. B288 _____

    D. 2345 _____

26. Encode each of the following commands in terms of the machine language described in

    A. _____ LOAD register 7 with the value A5.

    B. _____ LOAD register 7 with the contents of the memory cell at address A5.

    C. _____ ADD the contents of registers 5 and 6 as thought they were values in two's complement notation and leave the result in register 4.

    D. _____ OR the contents of registers 5 and 6, leaving the result in register 4.

27. The following table shows a portion of a machine's memory containing a program written in the language described in the language description table. Answer the questions below assuming that the machine is started with its program counter containing 00.

address	content
00	21
01	0B
02	14
03	04
04	C0
05	00

A. What bit pattern will be in register 4 when the machine halts?

B. What bit pattern will be in register 1 when the machine halts?

28. The following table shows a portion of a machine's memory containing a program written in the language described in the language description table. Answer the questions below assuming that the machine is started with its program counter containing 00.

address	content
00	25
01	03
02	A5
03	02
04	35
05	03
06	24
07	00
08	34
09	04
0A	B0
0B	03
0C	C0
0D	00

A. What bit pattern will be in register 5 when the machine halts?

B. What bit pattern will be in the program counter when the machine halts?

C. What bit pattern will be at memory location 04 when the machine halts?

29. Given the following Python program, write a machine language program equivalent to it in the machine language given at the end of this paper and briefly explain it.

```
x = 0
while x < 5:
    x = x + 1
print x
```

Try all the programs you write on the simulator and verify that it produces the expected results. https://github.com/Megadardery/machine-language/releases

CS111: Fundamentals of CS
Sheet 3 – Version 4.0

Cairo University, Faculty of Computers and Artificial Intelligence

6. Python

Read about Python standard types. https://docs.python.org/3/library/stdtypes.html

30. Develop two functions to encrypt and decrypt a given text in Caesar cypher. Given a text to encrypt, alphabetic characters are all shifted by one and spaces are removed. To decrypt the text, the opposite process is followed but spaces are not recovered. Notice that 'z' turns to 'a'. And all encryption is done on small letters version of the message.

Sample input:	I love Python Programming.	My home is 3 Zewail Street, Dokki.
Encryption:	jmpwfqzuipoqsphbnnjoh.	nzipnfjt3afxbjmtusffu,epllj.
Decryption:	ilovepythonprogramming.	myhomeis3zewailstreetdokki.

You might want to use the built-in function **`ord`**, which converts a character to a numeric code, and **`chr`**, which converts numeric codes to characters. Letters of the alphabet are encoded in alphabetical order, so for example:

```
>>> ord('c') - ord('a')
2
```

31. Develop a Python function that checks if two lists have the same elements, even if not in order. Do not use built in functions.

Sample input:	[1, 2, 3, 4, 5, 6, 7, 8]	and	[8, 7, 6, 5, 4, 3, 2, 1]
Output:	Lists are equal = True		
Sample input:	[1, 2, 3, 4, 44, 6, 7, 8]	and	[8, 7, 6, 5, 4, 3, 2, 1]
Output:	Lists are equal = False		

32. Repeat the same exercise (37) using built-in functions.

33. Write a Python function that checks that a given list is sorted in ascending order, descendant order or not sorted. It should return 1 for ascending and -1 for descending and 0 for not sorted.

Sample inputs:	[1, 2, 3, 4, 5, 6, 7, 8]	[8, 7, 6, 5, 4, 3, 2, 1]	[4, 5, 6, 3, 2, 9]
Outputs:	1	-1`	0

34. **Number scrabble** is played with the list of numbers between 1 and 9. Each player takes turns picking a number from the list. Once a number has been picked, it cannot be picked again. If out of the number a player has picked so far, three numbers add up to 15, that player wins the game. However, if all the numbers are used and no player gets exactly 15, the game is a draw.

Example: (1) 4 (2) 7 (1) 3 (2) 8 (1) 5 (2) 6 (1) 1 (2) 2 => 2 wins (7 + 6 + 2 = 15)

35. **Subtract a square**. This is a two-player mathematical game of strategy. It is played by two people with a pile of coins (or other tokens) between them. The players take turns removing coins from the pile, always removing a non-zero square number of coins (1, 4, 9, 16, …). The player who removes the last coin wins.

Example of this game is at: http://delphiforfun.org/Programs/SubtractingSquares.htm

Hint: Modify the Nim game written in the lecture and available in course page to do this .

36. Write a Python program that takes two file names and copies the first file to the second one.

37. Write a Python program that takes a file name, opens the file, reads it and prints its content in reverse order.

38. Write a Python program that opens the file and counts the number of words, lines and characters in it.

39. Create a dictionary with 10 or more Egyptian cities. City name is the key, while the value to store population. Or it can be the distance from Cairo. Then the program that allows the user to choose from three functions; Listing all cities and their information, query the dictionary for a city or add a new city.

40. Write a Python function that loads the most common English words from a file (See https://github.com/first20hours/google-10000-english/blob/master/google-10000-english.txt) into a dictionary where word is the key and value is the number of letters in the word (length). Then write another functions that allows the user to display all words of certain length, for example can display English words of three letters only, four letters only, etc.

Cairo University, Faculty of Computers
and Artificial Intelligence

Machine Language

Op-code	Operand	Description
1	RXY	LOAD the register R with the bit pattern found in the memory cell whose address is XY. *Example:* 14A3 would cause the contents of the memory cell located at address A3 to be placed in register 4.
2	RXY	LOAD the register R with the bit pattern XY. *Example:* 20A3 would cause the value A3 to be placed in register 0.
3	RXY	STORE the bit pattern found in register R in the memory cell whose address is XY. *Example:* 35B1 would cause the contents of register 5 to be placed in the memory cell whose address is B1.
3	**R00**	**STORE to location 00, which is a memory mapping for the screen. Writing to 00 is writing to screen.**
4	0RS	MOVE the bit pattern found in register R to register S. *Example:* 40A4 would cause the contents of register A to be copied into register 4.
5	RST	ADD the bit patterns in registers S and T as though they were two's complement representations and leave the result in register R. *Example:* 5726 would cause the binary values in registers 2 and 6 to be added and the sum placed in register 7.
6	RST	ADD the bit patterns in registers S and T as though they represented values in floating-point notation and leave the floating-point result in register R. *Example:* 634E would cause the values in registers 4 and E to be added as floating-point values and the result to be placed in register 3.
7	RST	OR the bit patterns in registers S and T and place the result in register R. *Example:* 7CB4 would cause the result of ORing the contents of registers B and 4 to be placed in register C.
8	RST	AND the bit patterns in register S and T and place the result in register R. *Example:* 8045 would cause the result of ANDing the contents of registers 4 and 5 to be placed in register 0.
9	RST	EXCLUSIVE OR the bit patterns in registers S and T and place the result in register R. *Example:* 95F3 would cause the result of EXCLUSIVE ORing the contents of registers F and 3 to be placed in register 5.
A	R0X	ROTATE the bit pattern in register R one bit to the right X times. Each time place the bit that started at the low-order end at the high-order end. *Example:* A403 would cause the contents of register 4 to be rotated 3 bits to the right in a circular fashion.
B	RXY	JUMP to the instruction located in the memory cell at address XY if the bit pattern in register R is equal to the bit pattern in register number 0. Otherwise, continue with the normal sequence of execution. (The jump is implemented by copying XY into the program counter during the execute phase.) *Example:* B43C would first compare the contents of register 4 with the contents of register 0. If the two were equal, the pattern 3C would be placed in the program counter so that the next instruction executed would be the one located at that memory address. Otherwise, nothing would be done and program execution would continue in its normal sequence.
C	000	HALT execution. *Example:* C000 would cause program execution to stop.