CIS 350 – INFRASTRUCTURE TECHNOLOGIES
HOMEWORK # 3

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(You may do this homework in groups of 2 students maximum.)

Topics: Data formats and standards, representing numerical data, and LMC assembly language (Chapters 4-6)

1. Approximately how many pages of pure 16-bit (2-byte) Unicode text can each of the following devices: (a) a 4.7GB DVD-ROM and (b) the Samsung 2TB (terabyte) Solid State Drive (SSD) hold? Assume that a typical page of text holds, say roughly 5,000 characters. (You must show your calculations!) Note 1TB = 1,024 GB

In 16-bit (2-byte) Unicode: each character takes 2 bytes
A page of 5000 characters takes 2*5000 = 10,000 bytes

(a) 4.7GB DVD-ROM

4.7 GB = 4.7 * 1024 * 1024 * 1024 = 5046586573 bytes

5046586573/10000 = 504,658.66 pages

(b) 2TB SSD

2 TB = 2 * 1024 * 1024 * 1024 * 1024 = 2199023255552 bytes

2199023255552/10000 = 219,902,325.60 pages

2. An analog wave representing the song by Lady Gaga and Bradley Cooper (ALWAYS REMEMBER US THIS WAY (LADY GAGA) - LEGENDADO - HD - YouTube from the movie "A Star is Born" is sampled with the frequency of 35,000Hz during its conversion from the analog form to the digital form. Assume that each sample is stored in 2 bytes. (You must show your calculations!) (Before you work this exercise, you may click on the above link to listen to this beautiful song.)

How many MB would it take to store 3 minutes and 26 seconds of the uncompressed sound?

One second of sound takes 35,000* 2 = 70,000 bytes
Time: 3*60+26 = 206 sec

70,000 * 206 = 14420000 bytes = 13.75 MB

If a compression ratio is 30:1, how many MB would that sound occupy after compression.

13.75/30 = 0.46 MB

3. Find the 16-bit (2-byte) 2's complementary binary representation for the decimal number $(-40)_{10}$. (Note that when you convert the 1's complement to 2's complement a carry maybe generated. You must show your calculations!)

1. $(40)_{10} = (101000)_2$
2. Pad 0s to form 16 bits: 0000000000101000
3. Find 1's complement of $(0000000000101000)_2$
   $(1111111111010111)_2$
4. Find 2's complement: 1111111111010111
   \+ 1

   1111111111011000

   $(-40) = (1111111111011000)_2$

   Check: $-1*2^{15} + 1*2^{14} + 1*2^{13} + 1*2^{12} + 1*2^{11} + 1*2^{10} + 1*2^9 + 1*2^8 + 1*2^7 + 1*2^6 + 0*2^5 + 1*2^4 + 1*2^3 + 0*2^2 + 0*2^1 + 0*2^0 = -40$

4. Use the World Wide Web as a resource to investigate MPEG-2 and MPEG-4 standards for videos. Explain briefly the data compression algorithm, if any, used by MPEG-2 and MPEG-4. Do they use lossy or lossless compression? Summarize your findings in the table below.

MPEG-2	MPEG-4
1. Suitable for encoding videos and compatible with DVD media 2. The size of MPEG2 videos is bigger in comparison to MPEG4. 3. Requires a broader bandwidth 4. Higher quality 5. Examples of extensions of MPEG2 are: .mp2, mp3, .mpeg, etc. 6. MPEG2 uses a simple algorithm for compression of files and provides a superior image quality. It uses a lossy compression method.	1. Suitable for portable devices and streaming videos from internet 2. The size of MPEG4 videos is smaller in comparison to MPEG2. 3. Requires a smaller bandwidth 4. Quality not as good as MPEG-2 5. Examples of extensions of MPEG4 are: .m4a, .m4b, .m4r, .mp4, etc. 6. MPEG4 provides the advantage of compressing the file in a way that the file size reduces. Its compression can be lossless.

5. Below is a Little Man program that solves exercise 6.9, p. 164, from textbook. The program is very similar to the LMC program which you will find in the lecture notes on Chapter 6 posted on Blackboard and discussed in Panopto. The difference is that the program below is somewhat simpler as it uses only 2 branches (BRZ 09 and BR 01), whereas the program in the lecture notes uses 3 branches (BRP 05, BR 10, and BR 01). First, try to understand each instruction thoroughly and then trace the execution of each instruction.

Address	Instruction (Mnemonics)
03	IN
04	STO 18
05	BRZ 12
06	IN
07	ADD 20
08	STO 20
09	LDA 18
10	SUB 19
11	BR 04
12	LDA 20
13	OUT
14	HLT

Address		Contents
18	DAT	? → 2 → 1 → 0 (decremented by 1 each time the loop is executed)
19	DAT	1
20	DAT	0

Assume now that the above program will only read 3 numbers. That is, the following numbers in this order will be placed, one at a time, in the In-basket: 2, 18, and 15, where 2 is the count of numbers that follow, and 18 and 15 are the numbers that are to be added. The first column in the table on page 3 shows the order in which the instructions from the program will be executed. Trace the execution of these instructions and determine the contents of the PC **before** and **after** each instruction is executed. Also, write down in the table the contents of the In-basket; Accumulator; Memory locations 18, 19, and 20; and Out-basket **after** each instruction is executed. Memory location 18 controls the loop. It initially contains an unknown value (?), then 2, next 1, and finally 0. Memory location 19 always contains 1. It is used to decrease the loop count by 1. Memory location 20 is initialized with 0, and finally it stores 33, the sum of 18 and 15. The entry 03 → 04 in the PC column means that the PC is 03 when the instruction IN started and is changed to 04 when the instruction IN is finished.

The sequence in which instructions are executed	PC before → after	In-basket	Accumulator	Memory location 18	Memory location 19	Memory location 20	Out-basket
IN	03 → 04	2	2	?	1	0	?
STO 18	04 → 05	2	2	2	1	0	?
BRZ 12	05 → 06	2	Not executed 2	2	1	0	?
IN	06 →07	18	18	2	1	0	?
ADD 20	07 → 08	18	18	2	1	0	?
STO 20	08 → 09	18	18	2	1	18	?
LDA 18	09 →10	18	2	2	1	18	?
SUB 19	10 → 11	18	1	2	1	18	?
BR 04	11 → 04	18	1	2	1	18	?
STO 18	04 → 05	18	1	1	1	18	?
BRZ 12	05 → 06	18	Not executed 1	1	1	18	?
IN	06 → 07	15	15	1	1	18	?
ADD 20	07 → 08	15	33	1	1	18	?
STO 20	08 → 09	15	33	1	1	33	?
LDA 18	09 → 10	15	1	1	1	33	?
SUB 19	10 → 11	15	0	1	1	33	?
BR 04	11 → 04	15	0	1	1	33	?
STO 18	04 → 05	15	0	0	1	33	?
BRZ 12	06 → 12	15	Executed 0	0	1	33	?
LDA 20	12 → 13	15	33	0	1	33	?
OUT	13 → 14	15	33	0	1	33	33
HLT	14 →14 Or 14 → 03	15 Or 0	33 Or 0	0 Or 0	1 Or 0	33 Or 0	33 Or 0