A -------- SOLUTIONS ---------A

MEF UNIVERSITY
Your Freedom in Learning

EE 306 Microprocessors Spring 2018 – 2019

Midterm Exam

27.03.2019

1. (20 pnt) Consider the program given in Table 1. Content of Stack pointer (SP, R13) is 0x00FFFF00 before the program is executed. Write the content of R0, R1, R2 and SP after each PUSH and POP instruction, into the shaded table cells. Stack grows upwards.

Table 1: Program memory

Content of general purpose registers:

Fill this part:

ADDRESS	INSTRUCTION	R0	R1	R2	SP
0x00000000	MOV R0, #0x18	0x00000018	--------	--------	0x00FFFF00
0x00000004	MOV R1, #0x21	0x00000018	0x00000021	--------	0x00FFFF00
0x00000008	MOV R2, #0x37	0x00000018	0x00000021	0x00000037	0x00FFFF00
0x0000000C	PUSH R2	0x00000018	0x00000021	0x00000037	0x00FFFFEC
0x00000010	POP R1	0x00000018	0x00000037	0x00000037	0x00FFFF00
0x00000014	PUSH R0	0x00000018	0x00000037	0x00000037	0x00FFFFEC
0x00000018	POP R2	0x00000018	0x00000037	0x00000018	0x00FFFF00

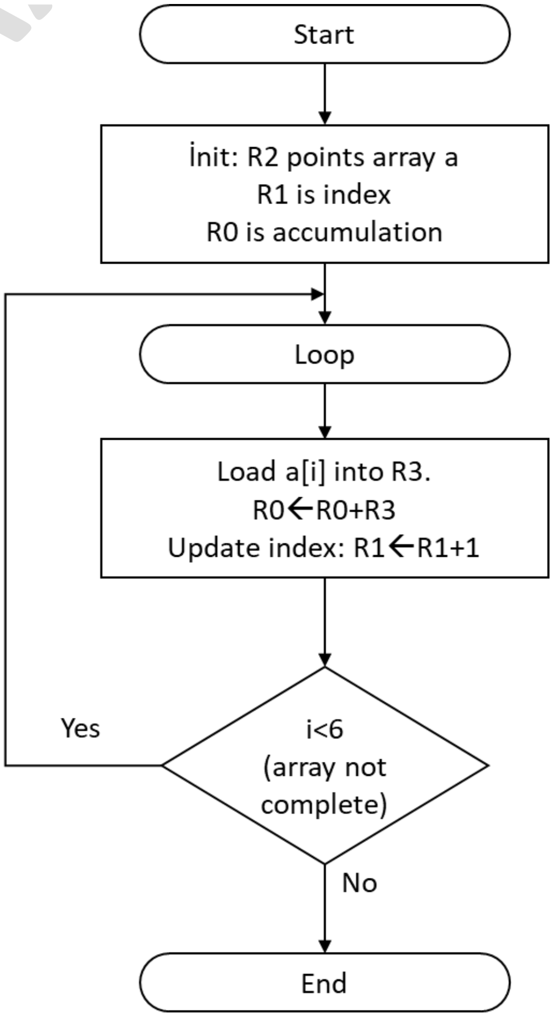
2. (20 pnt) For loop.

a. Translate the following C code to ARM assembly.

```
accu = 0;
for (i = 0; i < 6; i + +) {
accu += a[i];
}
```

```
      MOV r0, #_0____        // r0 will hold accumulation, initialize!
      MOV r1, #_0____        // first element's index
      LDR r2, =arraya        // load the address of array
Loop:
      LDR r3,[r2__,r1__,LSL #2__] // load value (a[i]) from memory
      ADD r0, r3, r0__          // sum += a[i]
      ADD r1, r1, #1  _         // update the index i= …
      CMP r1, #6___             // check the index, i
      BLT Loop                  // loop only if i….
done: B done
arraya: .word 12, 28, 43, 46, 23, 876
```

b. Draw the flow chart.



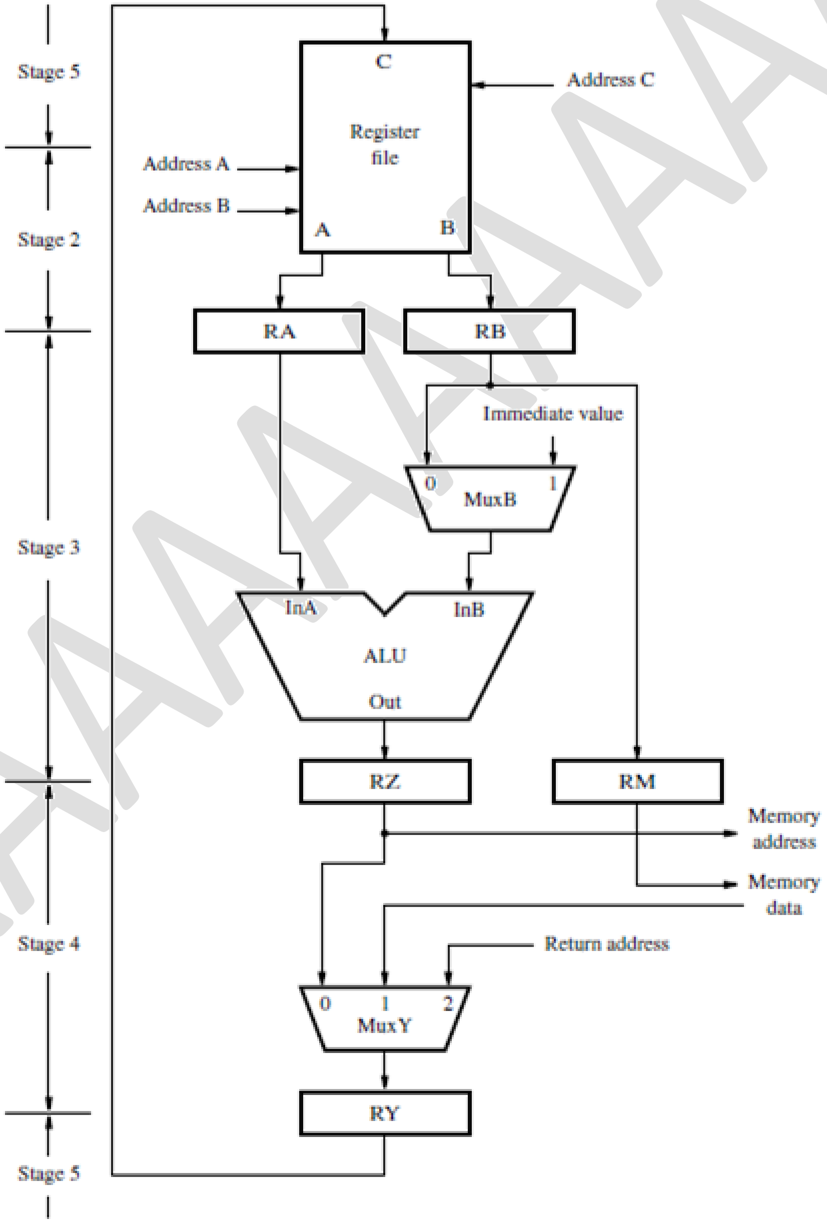
3. (20 pnt) The instruction

```
    SUBS R4, R5, #1
```

is stored in location 0x37C0 in the memory. At the time this instruction is fetched, registers R4 and R5 contain the values 0x1000 and 0x1004, respectively. The memory locations 0x1000 and 0x1004 contain the values 0x3214 and 0xA105.

Write the 5 execution steps for this instruction. While listing the steps, give the values in registers **R4, RA, RB, RM, RZ**, and **RY** whenever they change as this instruction is executed.

Note: Datapath flow is given in the figure. SUBS instruction performs as ARM instruction set.



1. Fetch instruction @0x37C0 address: Address 🡐 [PC], IR 🡐 [0x37C0], PC 🡐 [PC] +4 = 0x37C4
2. Decode instruction: RA 🡐 R5 = 0x1004, RB 🡐 0x1,
3. ALU operation, SUB: InA = 0x1004, InB= 0x1, RZ = 0x1003
4. Write: RY 🡐 0x1003
5. Write: R4🡐 0x1003

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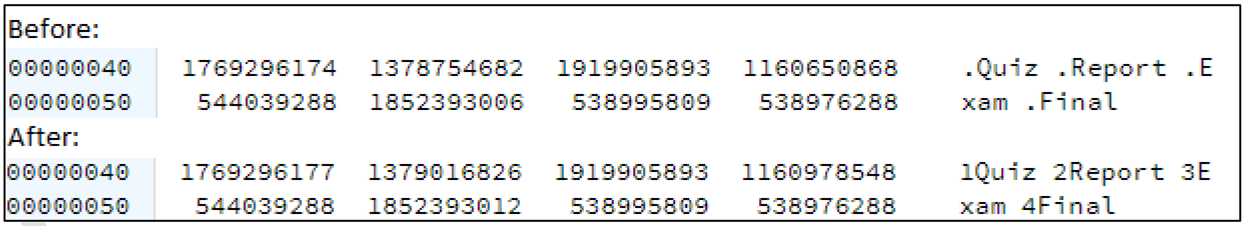
4. (40 pnt) ASCII codes of ".Quiz .Report .Exam .Final" text contains 26 characters: letters, dots and whitespace. We write the ARM assembly program in Fig. 2.1 to make a list out of this text. After this program is executed, the dots will be replaced by numbers: " 1Quiz 2Report 3Exam 4Final" and all characters will occupy their old locations, as shown in Fig. 2.2. ASCII code for dot and numbers are given in Fig. 2.3.

- **a.** Draw the flowchart of your program.
- **b.** Write LOOP subroutine
- **c.** Explain each step of your program.

```
.global _start
_start:

MOV R0, #26 // NUMBER OF CHARACTERS
LDR R1, =CHAR // FIRST CHAR ADDRESS
MOV R3, #_____ // Ascii for 0.
LOOP:
      CMP R0,#0            // if all characters are converted

      BEQ done             // we finish the loop

      LDRB R2,[R1]         // read the ASCII byte pointed by R1

      CMP R2,#0x2e         // dot

      ADDEQ R3,R3,#1       // update list order

      MOVEQ R2,R3

      STRB R2,[R1]         // update dot with number

      ADD R1,R1,#1         // next byte is located "1" address away.

      SUB R0,R0,#1         // keep how many characters are analyzed.


END: B END

CHAR: .byte 0x2e, 0x51, 0x75, 0x69, 0x7a, 0x20, 0x2e, 0x52,
0x65, 0x70, 0x6f, 0x72, 0x74, 0x20, 0x2e, 0x45, 0x78, 0x61,
0x6d, 0x20, 0x2e, 0x46, 0x69, 0x6e, 0x61, 0x6c
.end
```

Fig. 2.1: Program

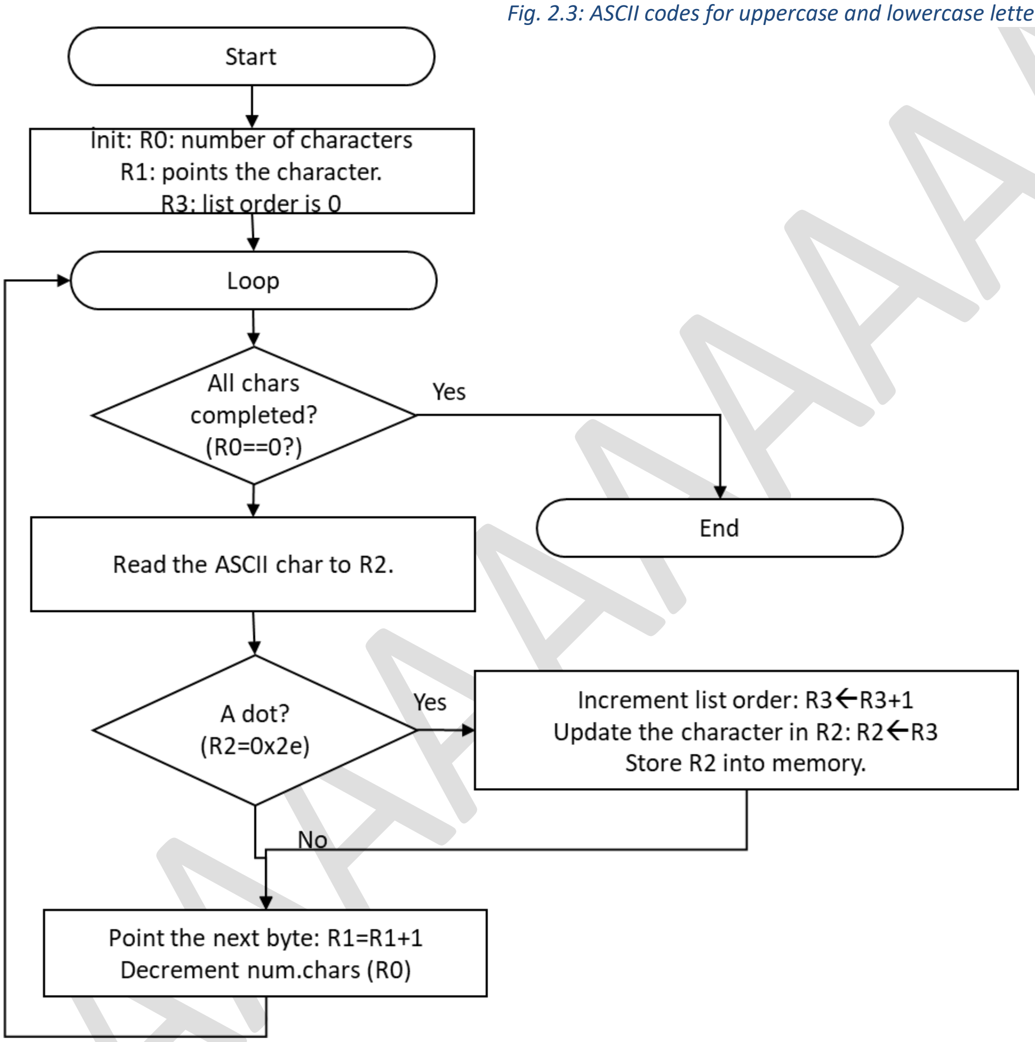


```
Before:
00000040   1769296174  1378754682  1919905893  1160650868    .Quiz .Report .E
00000050    544039288  1852393006   538995809   538976288    xam .Final
After:
00000040   1769296177  1379016826  1919905893  1160978548    1Quiz 2Report 3E
00000050    544039288  1852393012   538995809   538976288    xam 4Final
```

Fig 2.2: Memory content before and after program execution.

Numbers	ASCII Codes
0	0x30
1	0x31
2	0x32
3	0x33
…	…
…	…
9	0x39
.	0x2e

Fig. 2.3: ASCII codes for uppercase and lowercase letters


Start
Init: R0: number of characters
R1: points the character.
R3: list order is 0
Loop
All chars
completed?
(R0==0?)
Yes
End
Read the ASCII char to R2.
A dot?
(R2=0x2e)
Yes
Increment list order: R3←R3+1
Update the character in R2: R2←R3
Store R2 into memory.
No
Point the next byte: R1=R1+1
Decrement num.chars (R0)