ARM ASSEMBLY LAB-1

By

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STATUS UPDATE

All the three items namely,

1. Setting up the environment
2. Setting up the tool
3. Exercise – Your Mnemonics

were attempted. Items 2 & 3 were completed successfully while setting up environment encountered permission issues (that are being rectified) despite enablement of user as collaborator to github.

EXERCISE – YOUR MNEMONICS

There are multiple ways to produce the mnemonics for same operation.

For this lab, not very fine tuned or optimized mnemonic sequence is used. Rather focus was to get the output correct.

Wherever feasible, multiple logics are mentioned and attempted too.

The mnemonics can be generated with multiple addressing modes. Code is not with all possible addressing modes & permutation/combination thereof.

Small numbers are assumed for function verification and coding at this moment.

In some files, multiple logics are attempted and only one is kept enabled.

XNOR R1, R2, R3

The optimal logic (in terms of instruction cycles) is –

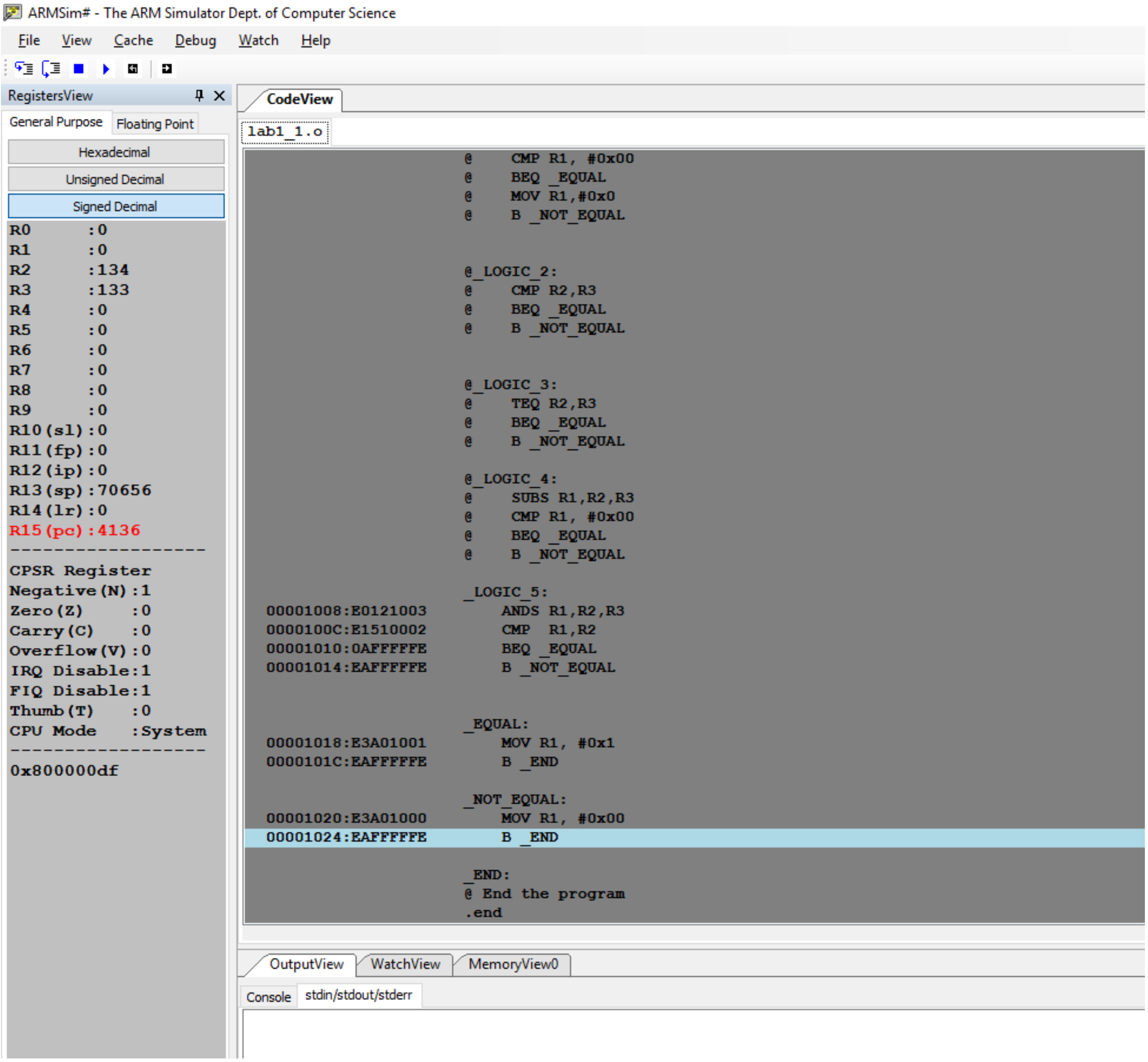
```
CMP R2,R3

BEQ _EQUAL

B _NOT_EQUAL
```

However, multiple logics are mentioned in the code file (**lab1_1.s**).

Here, logical XNOR is assumed.

This essentially means – the output would be either true (1) or false (0) and not the bitwise XNOR value.

The sample output screenshot for one of the logic is –



```
R0        :0
R1        :0
R2        :134
R3        :133
R4        :0
R5        :0
R6        :0
R7        :0
R8        :0
R9        :0
R10(sl):0
R11(fp):0
R12(ip):0
R13(sp):70656
R14(lr):0
R15(pc):4136
------------------
CPSR Register
Negative(N):1
Zero(Z)     :0
Carry(C)    :0
Overflow(V):0
IRQ Disable:1
FIQ Disable:1
Thumb(T)    :0
CPU Mode    :System
------------------
0x800000df
```

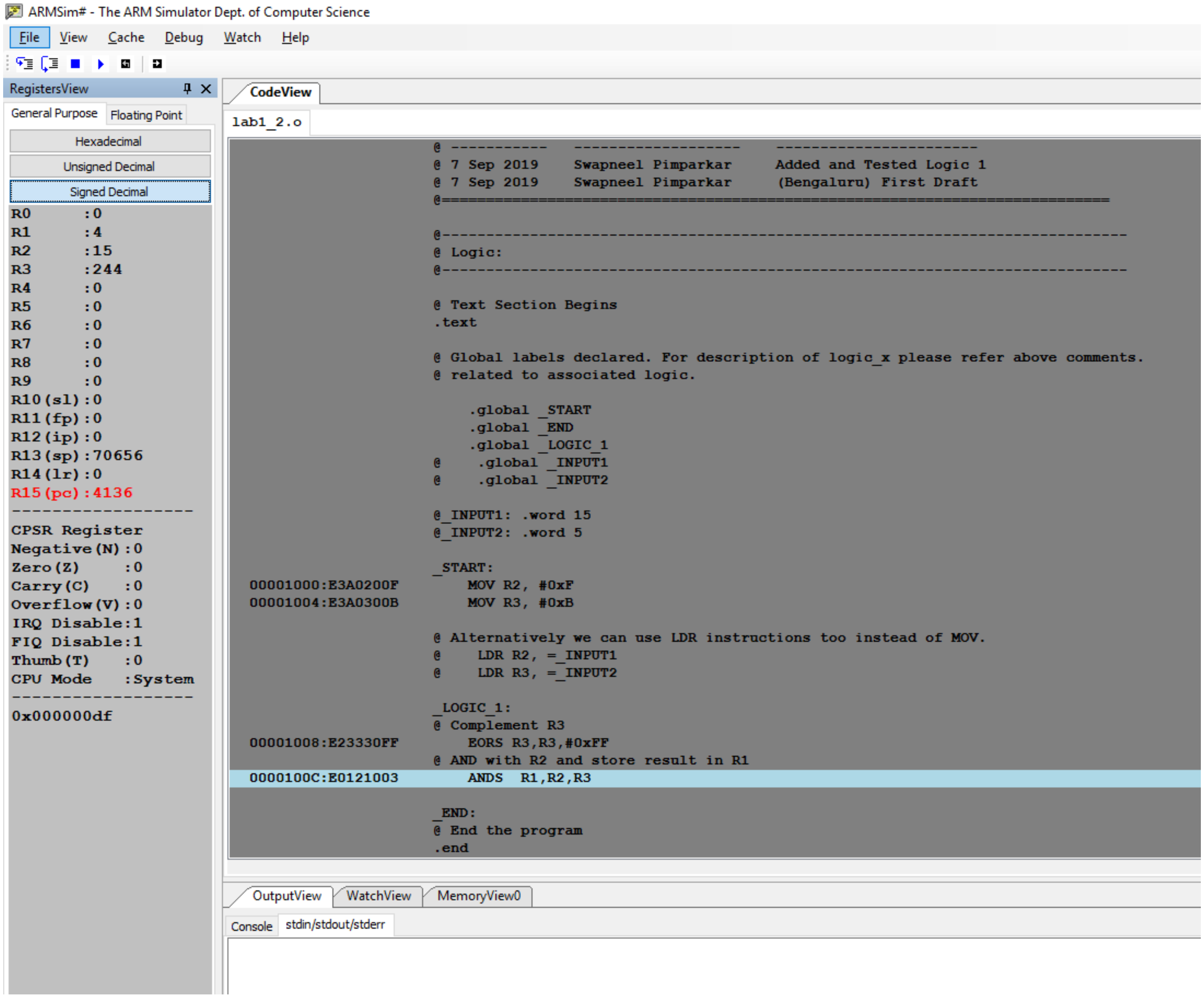
```
                        @     CMP R1, #0x00
                        @     BEQ _EQUAL
                        @     MOV R1,#0x0
                        @     B _NOT_EQUAL


                        @_LOGIC_2:
                        @     CMP R2,R3
                        @     BEQ _EQUAL
                        @     B _NOT_EQUAL


                        @_LOGIC_3:
                        @     TEQ R2,R3
                        @     BEQ _EQUAL
                        @     B _NOT_EQUAL

                        @_LOGIC_4:
                        @     SUBS R1,R2,R3
                        @     CMP R1, #0x00
                        @     BEQ _EQUAL
                        @     B _NOT_EQUAL

                        _LOGIC_5:
00001008:E0121003           ANDS R1,R2,R3
0000100C:E1510002           CMP  R1,R2
00001010:0AFFFFFE           BEQ _EQUAL
00001014:EAFFFFFE           B _NOT_EQUAL


                        _EQUAL:
00001018:E3A01001           MOV R1, #0x1
0000101C:EAFFFFFE           B _END

                        _NOT_EQUAL:
00001020:E3A01000           MOV R1, #0x00
00001024:EAFFFFFE           B _END

                        _END:
                        @ End the program
                        .end
```

BITWISE AND OF R2 & COMPLEMENT OF R3

The essential logic in corresponding file **(lab1_2.s)** is -

```
@ Complement R3
   EORS R3,R3,#0xFF
@ AND with R2 and store result in R1
   ANDS  R1,R2,R3
```

And the corresponding sample output screenshot is –



```
R0       :0
R1       :4
R2       :15
R3       :244
R4       :0
R5       :0
R6       :0
R7       :0
R8       :0
R9       :0
R10(sl):0
R11(fp):0
R12(ip):0
R13(sp):70656
R14(lr):0
R15(pc):4136
-----------------
CPSR Register
Negative(N):0
Zero(Z)     :0
Carry(C)    :0
Overflow(V):0
IRQ Disable:1
FIQ Disable:1
Thumb(T)    :0
CPU Mode    :System
-----------------
0x000000df
```

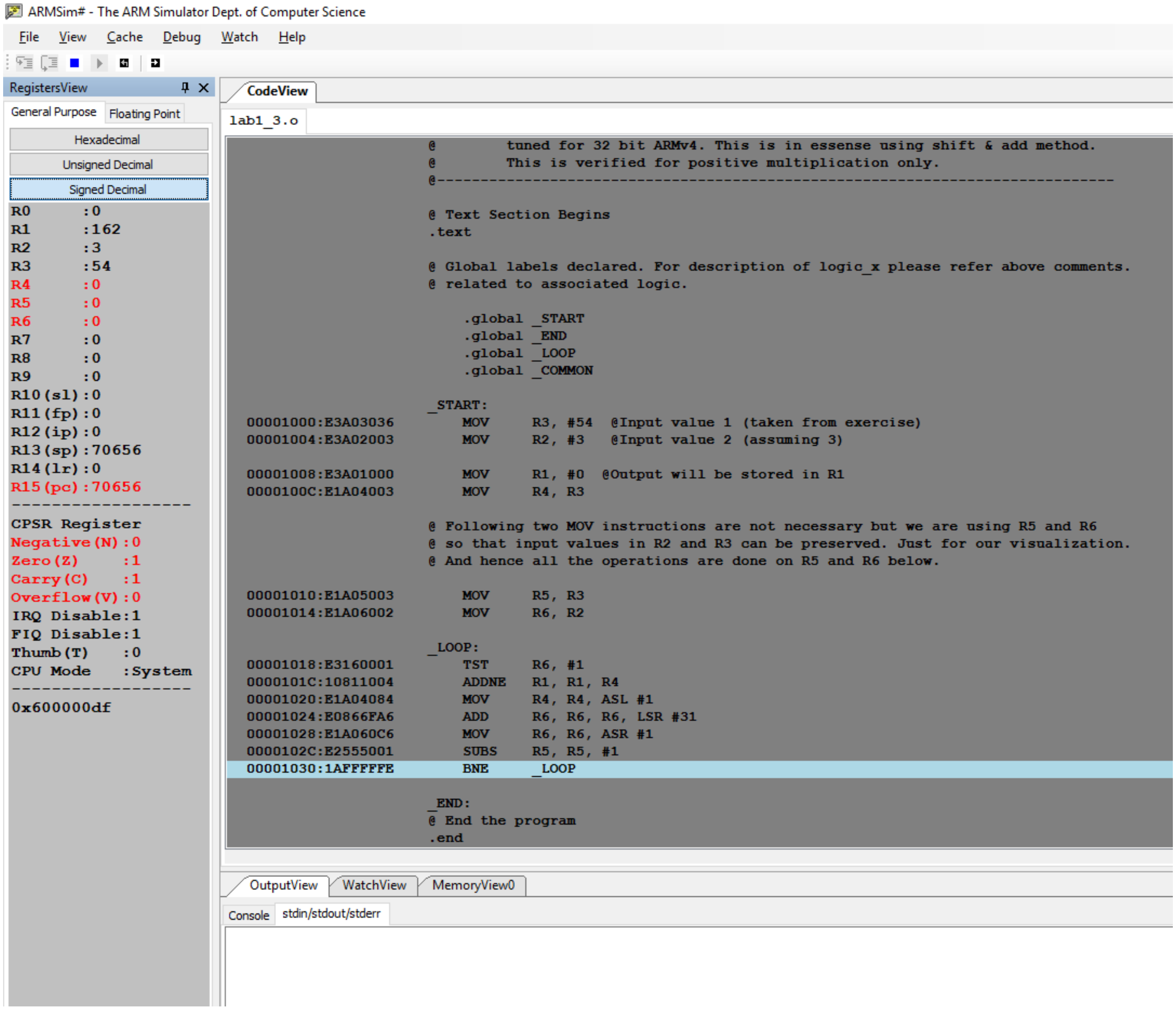
```
                         @ -----------    -------------------    -----------------------
                         @ 7 Sep 2019     Swapneel Pimparkar     Added and Tested Logic 1
                         @ 7 Sep 2019     Swapneel Pimparkar     (Bengaluru) First Draft
                         @==============================================================================

                         @-------------------------------------------------------------------------------
                         @ Logic:
                         @-------------------------------------------------------------------------------

                         @ Text Section Begins
                         .text

                         @ Global labels declared. For description of logic_x please refer above comments.
                         @ related to associated logic.

                             .global _START
                             .global _END
                             .global _LOGIC_1
                         @     .global _INPUT1
                         @     .global _INPUT2

                         @_INPUT1: .word 15
                         @_INPUT2: .word 5

                         _START:
00001000:E3A0200F            MOV R2, #0xF
00001004:E3A0300B            MOV R3, #0xB

                         @ Alternatively we can use LDR instructions too instead of MOV.
                         @     LDR R2, =_INPUT1
                         @     LDR R3, =_INPUT2

                         _LOGIC_1:
                         @ Complement R3
00001008:E23330FF            EORS R3,R3,#0xFF
                         @ AND with R2 and store result in R1
0000100C:E0121003            ANDS  R1,R2,R3

                         _END:
                         @ End the program
                         .end
```

FAST MULTIPLICATION WITHOUT MUL

Assumed is Integer Multiplication only. First a C program without '*' operator was written so that MUL variants of instructions are not generated by compiler.

The code file for this exercise is named – **lab1_3.s**

Here is the sample output –



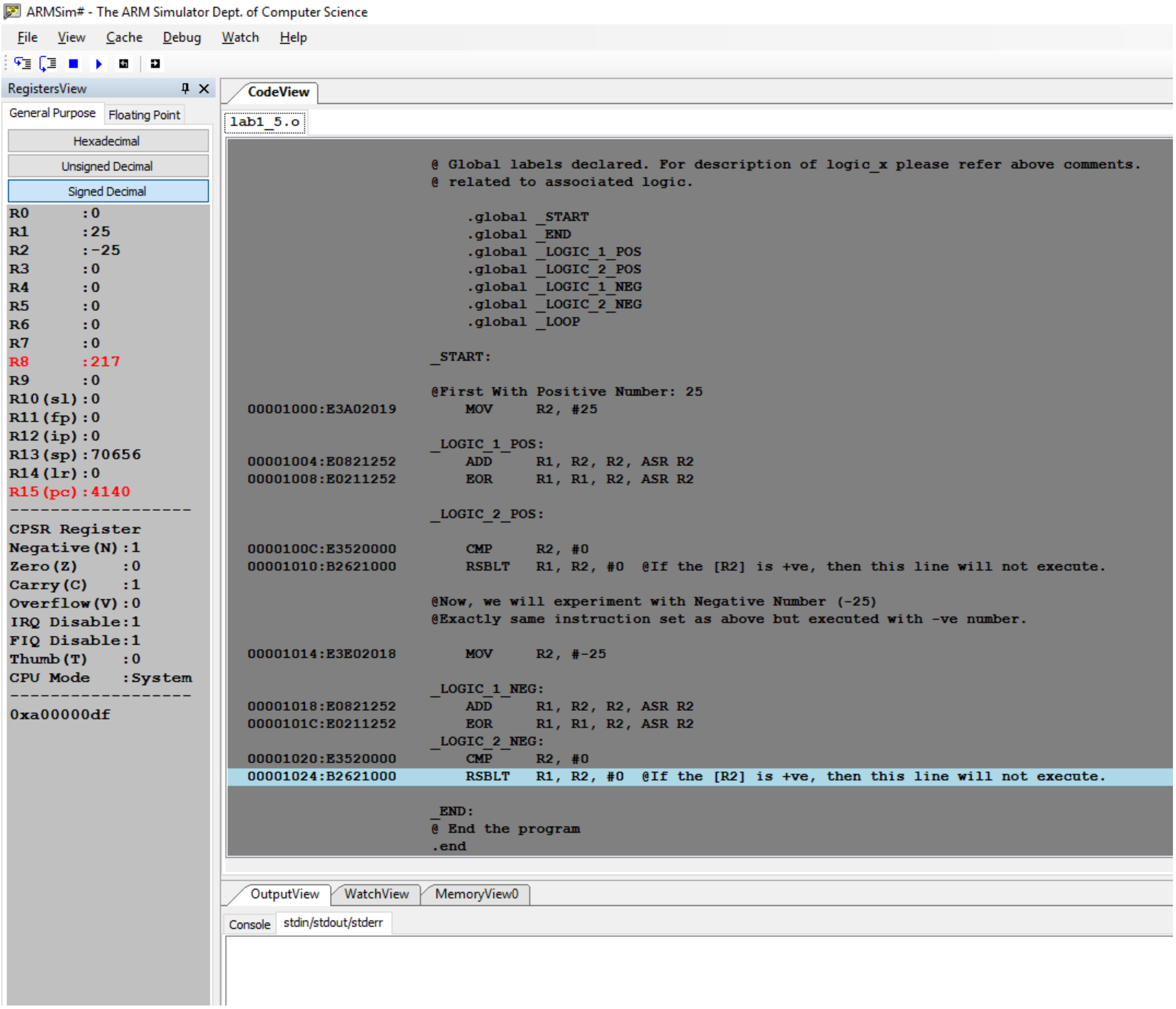
```
R0      :0
R1      :162
R2      :3
R3      :54
R4      :0
R5      :0
R6      :0
R7      :0
R8      :0
R9      :0
R10(sl):0
R11(fp):0
R12(ip):0
R13(sp):70656
R14(lr):0
R15(pc):70656
------------------
CPSR Register
Negative(N):0
Zero(Z)     :1
Carry(C)    :1
Overflow(V):0
IRQ Disable:1
FIQ Disable:1
Thumb(T)    :0
CPU Mode    :System
------------------
0x600000df
```

```
                        @        tuned for 32 bit ARMv4. This is in essense using shift & add method.
                        @        This is verified for positive multiplication only.
                        @------------------------------------------------------------------------------

                        @ Text Section Begins
                        .text

                        @ Global labels declared. For description of logic_x please refer above comments.
                        @ related to associated logic.

                            .global _START
                            .global _END
                            .global _LOOP
                            .global _COMMON

                        _START:
00001000:E3A03036           MOV     R3, #54  @Input value 1 (taken from exercise)
00001004:E3A02003           MOV     R2, #3   @Input value 2 (assuming 3)

00001008:E3A01000           MOV     R1, #0  @Output will be stored in R1
0000100C:E1A04003           MOV     R4, R3

                        @ Following two MOV instructions are not necessary but we are using R5 and R6
                        @ so that input values in R2 and R3 can be preserved. Just for our visualization.
                        @ And hence all the operations are done on R5 and R6 below.

00001010:E1A05003           MOV     R5, R3
00001014:E1A06002           MOV     R6, R2

                        _LOOP:
00001018:E3160001           TST     R6, #1
0000101C:10811004           ADDNE   R1, R1, R4
00001020:E1A04084           MOV     R4, R4, ASL #1
00001024:E0866FA6           ADD     R6, R6, R6, LSR #31
00001028:E1A060C6           MOV     R6, R6, ASR #1
0000102C:E2555001           SUBS    R5, R5, #1
00001030:1AFFFFFE           BNE     _LOOP

                        _END:
                        @ End the program
                        .end
```

Fast Division

The logic is simple here. For simplicity (and understanding), two loops are used instead of one. First loop is essentially for adjusting smaller divisor to that of larger dividend. And second loop is essentially with successive subtract. Only one loop could have been used too. The code file is **lab1_5.s**.

Corresponding sample output is –



```
R0      :0
R1      :25
R2      :-25
R3      :0
R4      :0
R5      :0
R6      :0
R7      :0
R8      :217
R9      :0
R10(sl):0
R11(fp):0
R12(ip):0
R13(sp):70656
R14(lr):0
R15(pc):4140
-----------------
CPSR Register
Negative(N):1
Zero(Z)    :0
Carry(C)   :1
Overflow(V):0
IRQ Disable:1
FIQ Disable:1
Thumb(T)   :0
CPU Mode   :System
-----------------
0xa00000df
```

```
                        @ Global labels declared. For description of logic_x please refer above comments.
                        @ related to associated logic.

                            .global _START
                            .global _END
                            .global _LOGIC_1_POS
                            .global _LOGIC_2_POS
                            .global _LOGIC_1_NEG
                            .global _LOGIC_2_NEG
                            .global _LOOP

                        _START:

                        @First With Positive Number: 25
00001000:E3A02019           MOV     R2, #25

                        _LOGIC_1_POS:
00001004:E0821252           ADD     R1, R2, R2, ASR R2
00001008:E0211252           EOR     R1, R1, R2, ASR R2

                        _LOGIC_2_POS:

0000100C:E3520000           CMP     R2, #0
00001010:B2621000           RSBLT   R1, R2, #0  @If the [R2] is +ve, then this line will not execute.

                        @Now, we will experiment with Negative Number (-25)
                        @Exactly same instruction set as above but executed with -ve number.

00001014:E3E02018           MOV     R2, #-25

                        _LOGIC_1_NEG:
00001018:E0821252           ADD     R1, R2, R2, ASR R2
0000101C:E0211252           EOR     R1, R1, R2, ASR R2
                        _LOGIC_2_NEG:
00001020:E3520000           CMP     R2, #0
00001024:B2621000           RSBLT   R1, R2, #0  @If the [R2] is +ve, then this line will not execute.

                        _END:
                        @ End the program
                        .end
```