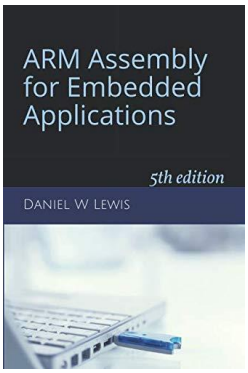

ARM Instructions Worksheet #11

Constant Multiples

Prerequisite Reading: Chapter 7
Revised: May 11, 2020

Objectives: *To use the web-based simulator ("CPULator") to better understand ...*

1. That multiplying by a constant requires two instructions – one to load a register with the constant followed by a `MUL`.
2. The use of a single addition or subtraction with shifting to compute N times a variable without multiplying.
3. The use of a two-instruction sequence to compute N times a variable in the same time as using a `MUL`.

To do offline: Answer the questions that follow the listing below. (Numbers at far left are memory addresses.)

```
                    .global     _start
                    .syntax     unified

00000000 _start:    LDR         R1,=1  // *** EXECUTION STARTS HERE ***

                    // Creating multiples using 1 instruction (faster than MUL)

00000004            LSL         R0,R1,3
00000008            ADD         R0,R1,R1,LSL 3
0000000C            RSB         R0,R1,R1,LSL 3
00000010            SUB         R0,R1,R1,LSL 3
00000014            MVN         R0,R1,LSL 3

                    // Creating multiples using 2 instructions (same time as MUL)

00000018            ADD         R0,R1,R1,LSL 2
0000001C            LSL         R0,R0,1

00000020            ADD         R0,R1,R1,LSL 2
00000024            ADD         R0,R1,R0,LSL 2

00000028            ADD         R0,R1,R1,LSL 4
0000002C            SUB         R0,R0,R1,LSL 2

00000030            RSB         R0,R1,R1,LSL 3
00000034            LSL         R0,R0,1

00000038            ADD         R0,R1,R1,LSL 2
0000003C            RSB         R0,R1,R0,LSL 2

00000040 done:      B           done   // Infinite loop

                    .end
```

What is in register `R0` after executing the `LSL` instruction at address 00000004_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `ADD` instruction at address 00000008_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `RSB` instruction at address $0000000C_{16}$? R0 (as decimal signed)

What is in register `R0` after executing the `SUB` instruction at address 00000010_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `MVN` instruction at address 00000014_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `LSL` instruction at address $0000001C_{16}$? R0 (as decimal signed)

What is in register `R0` after executing the `ADD` instruction at address 00000024_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `SUB` instruction at address $0000002C_{16}$? R0 (as decimal signed)

What is in register `R0` after executing the `LSL` instruction at address 00000034_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `RSB` instruction at address $0000003C_{16}$? R0 (as decimal signed)

Getting ready: Now use the simulator to collect the following information and compare to your earlier answers.

1. Click here to open a browser for the ARM instruction simulator with pre-loaded code.
2. Change the number format in the "Settings" window to signed decimal.

***Step 1:** Press F2 once per ARM instruction as needed to see what the simulator says for the following:*

What is in register `R0` after executing the `LSL` instruction at address 00000004_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `ADD` instruction at address 00000008_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `RSB` instruction at address $0000000C_{16}$? R0 (as decimal signed)

What is in register `R0` after executing the `SUB` instruction at address 00000010_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `MVN` instruction at address 00000014_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `LSL` instruction at address $0000001C_{16}$? R0 (as decimal signed)

What is in register `R0` after executing the `ADD` instruction at address 00000024_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `SUB` instruction at address $0000002C_{16}$? R0 (as decimal signed)

What is in register `R0` after executing the `LSL` instruction at address 00000034_{16}? R0 (as decimal signed)

What is in register `R0` after executing the `RSB` instruction at address $0000003C_{16}$? R0 (as decimal signed)