

## Brief Solutions to Tutorial 2

### 2.1 ARM Addressing Modes, their Characteristics and Applications

(1) and (2) Solutions:

No.	Mnemonics	Source addressing mode	Content in R0
1.	MOV R0 ,R2	Register Direct	0x00000004
2.	MOV R0 ,#0x0100	Immediate	0x00000100
3.	LDR R0 , [R1]	Register Indirect	0x00000102
4.	LDR R0 , [R1 , #4]	Base plus Offset (Pre-index)	0xFFFEAABB
5.	LDR R0 , [R1 , R2]	Base plus Index Register (Pre-index)	0xFFFEAABB
6.	LDR R0 , [R1 , #4] !	Offset with Autoindexing (Pre-index)	0xFFFEAABB
7.	LDR R0 , [R1] , #4	Offset with Autoindexing (Post-index)	0x00000102
8.	LDR R0 , [R1 , R2] !	Index Register with Autoindexing (Pre-index)	0xFFFEAABB
9.	LDR R0 , [R1] , R2	Index Register with Autoindexing (Post-index)	0x00000102

**Table 1\_Answers – The different ARM addressing modes and its effects on R0 after execution**

(3) Solutions:

- (a) Register direct -     **MOV R0 ,R3**
- (b) Immediate -         **MOV R0 ,#0x100**  
                              **ADD R0 ,R0 ,#2**
- (c) Register indirect - **MOV R0 , [R1]**

(4) Solutions:

- (a) Register indirect.
- (b) Register direct.
- (c) Immediate.

(5) **LDR R0 , [R1]**  
     **STR R0 , [R1 , #4]**

(6) Method 1 (less efficient)

```

      ADD R3 ,R1 ,#0x1C
      SUB R2 ,R3 ,#4
      :                               ; setup loop structure
Loop  LDR R0 , [R2]
      STR R0 , [R3]
      SUB R3 ,R3 ,#4
      SUB R2 ,R2 ,#4
      :                               ; loop back until 7 loops done
  
```

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Method 2 (more efficient)

```
        ADD R3,R1,#0x1C
        :                               ; setup loop structure
Loop    LDR R0,[R3,#-4]
        STR R0,[R3], #-4
        :                               ; loop back until 7 loops done
```

(7) Swap registers

```
MOV R4,R2
MOV R2,R3
MOV R3,R4
```

Swap memory locations

```
LDR R2,[R1]
LDR R3,[R1,#4]
STR R2,[R1,#4]
STR R3,[R1]
```

(8) Full Descending stack

```
Push R0 into a FD stack -      STR R0,[SP,#-4]!
Pop word from FD stack into R1 - LDR R1,[SP],#4
```

### 2.2 Arithmetic and Logical Instructions

(1) Possible solutions:

- a. **MOV R0,#0**
- b. **SUB R0,R0,R0**
- c. **EOR R0,R0,R0**
- d. **AND R0,R0,#0**

(2) Possible solution:

```
MOV R0,#0x11
ADD R0,R0,#0x1100
ADD R0,R0,#0x11000000
ORR R2,R2,R0
```

(3) Possible solution:

```
EOR R2,R2,R3
EOR R3,R2,R3
EOR R2,R2,R3
```

(4) Possible solutions:

```
ADD R0,R0,R0,LSL #3
```

(i) **0x7FFFFFFF/9 = 0xE38E38E (238,609,294).**

(ii) **RSB R0,R0,R0,LSL #3**

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### 2.3 ARM Assembly Program Analysis – Comparison and Counting

(1) Solutions:

```
R0 = 0x00000007
R1 = 0x00000109
R2 = 0x00000003
R3 = 0x00000080
R4 = 0x00000101
HotDays (0x100) = 0x03
DaySum (0x101) = 0x07
```

(2) The program computes the total number of days (**DaySum**) by counting number of byte-sized values retrieved before the value -128 (**0x80**) is encountered. It also counts the number of values that are larger than or equal to the decimal value 36 (i.e. **0x24**) and leave the result in memory variable **HotDays**.

(3) Possible solution:

```
Start      MOV     R4, #0x100    ; initialise R4 to point to start of memory data 0x100
           ADD     R1, R4, #1    ; initialise array pointer R1 to point to 0x101
           MOV     R0, #0        ; clear DaySum counter register R0
           MOV     R2, R0        ; clear HotDays counter register R2
Loop       LDRB    R3, [R1, #1]! ; use index with pre-increment to access next element
           CMP     R3, #0x80     ; compare array element in R3 with terminator 0x80
           BEQ     Done         ; branch to Done if equal to terminator
           ADD     R0, R0, #1    ; increment DaySum counter register R0
           CMP     R3, #36      ; compare array element in R3 with threshold 0x24
           BHS     HotFound     ; branch to HotFound if >= 0x24
           B       Loop        ; branch back to Loop
HotFound   ADD     R2, R2, #1    ; increment HotDays counter register R2
           B       Loop        ; branch back to Loop
Done       STRB    R2, [R4]     ; store R2 into HotDays memory variable at 0x100
           STRB    R0, [R4, #1]! ; store R0 into DaySum mem var at 0x101 and inc R4
           END
```

Note: Proposed optimized code executes in 93 clock cycles (savings of 34 clock cycles).

(4) **BHS HotFound** is a conditional branch for unsigned values. It needs to be changes to **BGE HotFound**. However, before the 32-bit comparison can be done, the byte read in from memory (which is zero-extended to 32 bits) must be sign-extended using the code segment below. This code segment must be inserted just before **CMP R3, #36**.

```
MOV     R5, #0
SUB     R7, R5, R3, LSR #7
ORR     R3, R3, R7, LSL #8
```