Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

School of Computer Science and Statistics
Trinity College Dublin
CS1021 / Introduction to Computing I

CS1021 Tutorial #2 Solution
Machine Code and Binary Arithmetic

1 Machine Code

(a) `0xE0850005`
    `0xE0800005`
    `0xE1A08007`
    `0xE0877000`
    `0xE1A09007`

(b) `ADD R5, R6, R8`

   `0xE0869008`

2 Addition of Binary Numbers

(a) `1111`

(b) `1000`

(c) `10010`

(d) `100010100`

3 Subtraction of Binary Numbers

(a) `100`

(b) `101`

4 Multiplication of Binary Numbers

Multiply the following binary values. Verify your solutions by converting the operands and results from binary to decimal.

(a) `100011`

(b) `10001111000`

Require $2n$ bits to store the result of the multiplication of two n-bit numbers

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

School of Computer Science and Statistics
Trinity College Dublin
CS1021 / Introduction to Computing I

5 Modulo Arithmetic

(a) 5 (0101)

(b) 1 (0001)

(c) 6 (0110)

6 2's Complement

(a) (i) $(-2^{8-1})\ldots 0 \ldots (+2^{8-1} - 1)$ *(or $-128\ldots 0\ldots +127$)*

(ii) $(-2^{16-1})\ldots 0 \ldots (+2^{16-1} - 1)$ *(or $-32,768\ldots 0\ldots +32,767$)*

(iii) $(-2^{32-1})\ldots 0 \ldots (+2^{32-1} - 1)$ *(or $-2,147,483,648\ldots 0\ldots +2,147,483,647$)*

(b) (i) 0000 0000

(ii) 0000 0100

(iii) 1111 1100

(iv) 0001 1011

(v) 1110 0101

(c) For each of the following arithmetic operations, convert the operands into their 8-bit binary equivalents, assuming a two's complement representation. Calculate the result using binary arithmetic. Convert the result back to decimal form to verify that you obtained the correct result.

(i) 0000 0000 (0_{10})

(ii) 1111 0110 (-10_{10})

(iii) 0000 0101 ($+5_{10}$)

(iv) 1000 0000 (-128_{10} – incorrect result – "overflow"!!)

7 64-bit and 128-bit Arithmetic

(a) 64-bit addition

```
1        ADDS    R1,  R3,  R5
2        ADC     R0,  R2,  R4
```

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

(b) 128-bit addition.

```
1          ADDS     R3, R11, R7
2          ADCS     R2, R10, R6
3          ADCS     R1, R9, R5
4          ADC      R0, R8, R4
```

(c) 64-bit subtraction.

```
1          SUBS     R1, R3, R5
2          SBC      R0, R2, R4
```

© **UNIVERSITY OF DUBLIN 2016**