# CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

# UNIVERSITY OF WISCONSIN—MADISON

Prof. Gurindar Sohi

TAs: Junaid Khalid and Pradip Vallathol

*Midterm Examination 1*

*In Class (50 minutes)*

*Friday, September 28, 2012*

*Weight: 17.5%*

**NO: BOOK(S), NOTE(S), OR CALCULATORS OF ANY SORT.**

The exam has nine pages. **Circle your final answers**. Plan your time carefully since some problems are longer than others. You **must turn in the pages 1-7**.

LAST NAME: ________________________________________________

FIRST NAME: ________________________________________________

ID# ________________________________________________

| Problem | Maximum Points | Points Earned |
|---|---|---|
| **1** | 1 | |
| **2** | 2 | |
| **3** | 4 | |
| **4** | 3 | |
| **5** | 2 | |
| **6** | 2 | |
| **7** | 3 | |
| **8** | 2 | |
| **9** | 3 | |
| **10** | 1 | |
| **11** | 2 | |
| **12** | 1 | |
| **13** | 4 | |
| **Total** | 30 | |

**Problem 1:** A picture is represented by a collection of pixels. Consider a picture format in which each pixel can be only one of 7 different shades. What is the minimum number of bits I would need to store a picture which contains 1024 pixels? **(1 Point)**

Minimum number of bits to represent 7 shades = 3 bits

So for 1024 pixels, number of bits = 1024 x 3 = 3072 bits

**Problem 2:** Consider a number **32** in an octal number system (base 8). What would be its representation in decimal? **(2 Points)**

$(32)_8 = 3 \times 8^1 + 2 \times 8^0 = 24 + 2 = (26)_{10}$

**Problem 3:** Let A = 5 ⅝ and B = 3 ¾. Convert them into their fixed point binary fraction form (use 8 bits, with 5 bits for the integer part and 3 bits for the fraction part) and then perform the following operation: A - B. Show your result both as a fixed point binary fraction and as a decimal fraction. **(4 Points)**

A = 0101.101

B = 0011.110

-B = 1100.010

A – B = A + (-B) = 0001.111 = 1.875

**Problem 4:** Show the result of performing the following logic operations on **X = 0xC8** and **Y = 0x0B**: (Express your answer in hexadecimal)
(**NOT** Y) **AND** (X **OR** Y) **(3 Points)**

X = 11001000

Y = 00001011

(NOT Y) AND (X OR Y) = 11110100 AND 11001011

= 11000000 = 0xC0

**Problem 5:** Consider a 16 bit binary number represented as 1011010010110100, with the right-most bit being bit 0, and the left-most bit being bit 15. I am interested in carrying out a bit-wise logical operation to extract the bits in the following bit positions: 1, 5, 7, 11 and 12. What mask should I use to get those interesting bits? Which logical operation would I use? **(2 Points)**

Mask = 0001100010100010

Logical operation to use is AND.

**Problem 6:** Convert the following binary code into an ASCII string (see attached ASCII table): **01100101 01000001 01110011 01011001** **(2 Points)**

= 0x 65 41 73 59 = e A s Y

**Problem 7:** Convert the two ASCII strings "**wE**" and "**Us**" into 16-bit binary strings (without the quotes; use 8 bits per character of the ASCII string). Now suppose that the resulting binary bits were 16-bit unsigned binary numbers, add these two binary strings. Show the result in binary. (See attached ASCII table **(3 Points)**

wE = 0x7745 = 0111011101000101

Us = 0x5573 = 0101010101110011

Sum = 1100110010111000

**Problem 8:** What is the decimal equivalent of the following 32-bit IEEE floating point number: **01000001001100000000000000000000** **(2 Points)**

0 10000010 01100000000000000000000 = $(-1)^{0} \times 1.375 \times 2^{(130-127)} = 11$

**Problem 9:** Add the following two 6-bit 2's complement binary numbers:
**101110 + 101001**
Is there an overflow? Explain why or why not. If there is an overflow, what could I do to mitigate this problem?
**(3 Points)**

Result = 1 | 010111

There is overflow, since we get a positive number on adding two negative numbers (or since there is a carry-out of the MSB and no carry-in to the MSB).

The problem can be mitigated by using more number of bits in the representation of the numbers.

**Problem 10:** Which of the following are specified by an ISA **(1 Point)**

(i) Data Type

(ii) Addressing

(iii) Microarchitecture

a) ii & iii

b) i & ii

c) i & iii

d) i, ii & iii

**Problem 11:** Put the following items/terms in order according to their level of abstraction relative to one another, label the most abstract 1 and least abstract 5. **(2 Points)**

| | |
|---|---|
| 2 | Algorithm to solve problem |
| 1 | Application |
| 4 | ISA |
| 3 | Code in High level language |
| 5 | Micro Architecture |

**Problem 12:** How many microarchitectures could exist for a single ISA? **(1 Point)**

a) None

b) 1

c) 2

d) There is no limit

**Problem 13:** Say we have a "black box" which takes two numbers as input and outputs their sum (see Figure 1(a)). Say we have another box capable of multiplying two numbers together (see Figure 1(b)). We can connect these boxes together to calculate p × (m + n) (see Figure 1(c)). Assume we have an unlimited number of these boxes. Show how to connect them together to calculate: **(4 Points)**

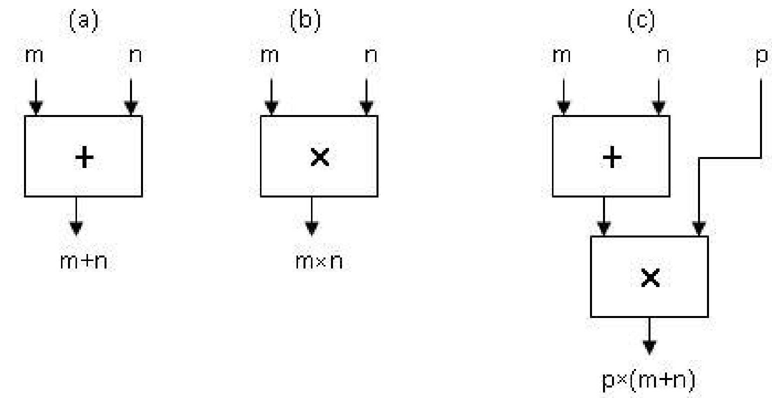
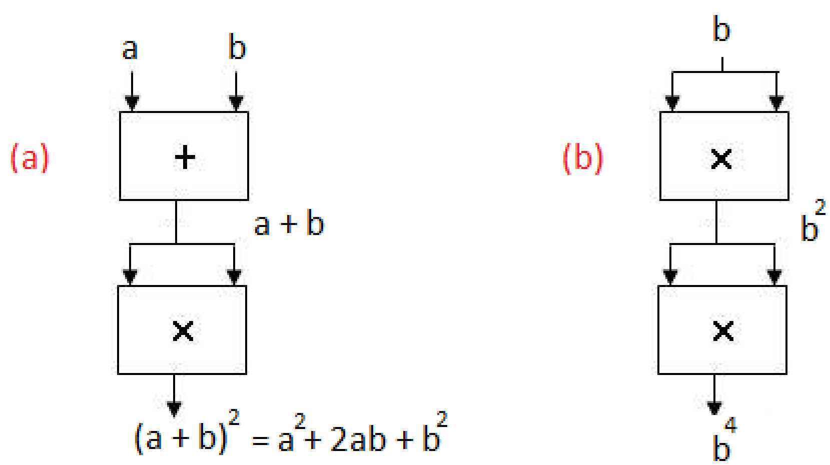



**Figure 1**

a) $a^2 + 2ab + b^2$ (Try to do this with a minimum number of boxes)
b) $b^4$



# ASCII Table

| Character | Hex | Character | Hex | Character | Hex | Character | Hex |
|---|---|---|---|---|---|---|---|
| nul | 00 | sp | 20 | @ | 40 | ` | 60 |
| soh | 01 | ! | 21 | A | 41 | a | 61 |
| stx | 02 | “ | 22 | B | 42 | b | 62 |
| etx | 03 | # | 23 | C | 43 | c | 63 |
| eot | 04 | $ | 24 | D | 44 | d | 64 |
| enq | 05 | % | 25 | E | 45 | e | 65 |
| ack | 06 | & | 26 | F | 46 | f | 66 |
| bel | 07 | ‘ (*Apostr.)* | 27 | G | 47 | g | 67 |
| bs | 08 | ( | 28 | H | 48 | h | 68 |
| ht | 09 | ) | 29 | I | 49 | i | 69 |
| lf | 0A | * | 2A | J | 4A | j | 6A |
| vt | 0B | + | 2B | K | 4B | k | 6B |
| ff | 0C | , *(Comma)* | 2C | L | 4C | l | 6C |
| cr | 0D | - | 2D | M | 4D | m | 6D |
| so | 0E | . *(Period)* | 2E | N | 4E | n | 6E |
| si | 0F | / | 2F | O | 4F | o | 6F |
| dle | 10 | 0 | 30 | P | 50 | p | 70 |
| dc1 | 11 | 1 | 31 | Q | 51 | q | 71 |
| dc2 | 12 | 2 | 32 | R | 52 | r | 72 |
| dc3 | 13 | 3 | 33 | S | 53 | s | 73 |
| dc4 | 14 | 4 | 34 | T | 54 | t | 74 |
| nak | 15 | 5 | 35 | U | 55 | u | 75 |
| syn | 16 | 6 | 36 | V | 56 | v | 76 |
| etb | 17 | 7 | 37 | W | 57 | w | 77 |
| can | 18 | 8 | 38 | X | 58 | x | 78 |
| em | 19 | 9 | 39 | Y | 59 | y | 79 |
| sub | 1A | : | 3A | Z | 5A | z | 7A |
| esc | 1B | ; | 3B | [ | 5B | { | 7B |
| fs | 1C | < | 3C | \ | 5C | \| | 7C |
| gs | 1D | = | 3D | ] | 5D | } | 7D |
| rs | 1E | > | 3E | ^ | 5E | ~ | 7E |
| us | 1F | ? | 3F | _ *(Undrscre)* | 5F | del | 7F |

**Extra page for hand written work, if needed. This page is not required and will NOT affect your grade. You don't even need to hand this page in.**