Midterm Exam 1

7-Oct-18

5 October 2018

___Key_______ , ___________

Last Name , First Name

Instructions:

- ***Show all work** on the **front** of the test papers. No work shown may mean 0 points given!* *If you need more room, make a clearly indicated note on the front of the page, "MORE ON BACK", and use the back. The back of the page will **not** be graded without an indication on the front.*
- ***Read** each question **carefully** and **follow the instructions**. Unless otherwise stated, **you must show your work and clearly illustrate your steps**.*
- *If you round a numerical answer, you must give at least **3 significant digits**.*
- *Put your name at the top of **each** test page and be sure your exam consists of the number of pages designated in the headers.*
- *The space provided does **NOT** necessarily represent the amount of writing necessary.*
- *You may **not** use any notes, homework, labs, or other books. Only **memoryless** calculator is allowed.*
- ***You may not use any notes, homework, labs, or other books.***

COMMENTS, FEEDBACK, or any special instructions for the professor:

Problem	Available	Points
1	20	
2	20	
3	20	
4	20	
5	20	
Total	100	

Important: *In completing this exam, I used a calculator with no communications capability, and no information of relevance to the course was stored in the calculator. I did not use any other electronic device or any other references. My work was solely my own.*

Your Calculator's Maker and Model#: _______________, **Signature:** __________________

You must sign this to receive credit for the exam.

Important Boolean Algebra Laws

Identity law
- A + 0 = A
- A·1 = A

Zero and One laws
- A + 1 = 1
- A·0 = 0

Associative laws
- A + (B + C) = (A + B) + C
- A· (B·C) = A· (B·C)

Distributive laws
- (B + C) = (A.B) + (B.C)
- A+(B·C) = (A+B) · (A+C)

DeMorgan's laws
- (A·B)'=A'+B'
- (A+B)'=A'·B'

Inverse laws
- A + A' = 1
- A·A' = 0

Commutative laws
- A + B = B + A
- A·B = B·A

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Remember to show ALL work here and in EVERY problem on this exam.

Q1. (Digital Logic and Binary Math, 20pts)

(a) Complete the truth table below and draw the logic circuit diagram of **AC+A'B+ABC'** [8pt]

A	*B*	*C*	AC+A'B+ABC'
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

(b) (i) How many kilobytes (kB) is 3.5×10^5 b? [7pts]

Solution:

$1\,KB = 2^{10}\ bytes = 2^{10}.2^3\ bits = 2^{13}\ bits$

$$So,\ 3.5 \times 10^5\ bits = \frac{3.5\times10^5}{2^{13}}\ KB = 42.725\ KB$$

Final answer: $\underline{\mathbf{42.725\ KB}}$

(ii) How many bits in 64 MB? [5pts]

Solution:

$1\,MB = 2^{20}\ bytes = 2^{20} \times 2^3\ bits = 2^{23}\ bits$

$64\ MB = 2^6\ MB = 2^6 \times 2^{23}\ bits = 2^{29}\ bits$

Final answer: $\underline{\mathbf{2^{29}\ bits}}$

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Q2. (2’s complement, 20pts) Do the following conversions between decimal number and **8-**bit **signed** integer in the **2’s complement** format. (**Note:** The binary numbers in this problem are **signed** 8-bit integers. When doing decimal-to-binary conversion, give your binary number answer in the same format. When doing binary-to-decimal conversion, indicate the sign of your decimal number answer.).

a) [10pts] -8_{10}

ANS:

11111000

b) [10pts] 11111110_2

ANS:

–2

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Q3. (Overflow detection, 20pts) Perform following binary calculations. Each number is an **8-bit signed integer** with 2's complement representation. **Give your answer in 8-bit 2's complement format and clearly state whether an overflow happens or not.** (**Note:** (1) your answer MUST BE 8-bit number. Deduction will be given for other type of representations. (2) If there is no overflow, you need to clearly state that an overflow does not happen)

a) [10pts] $11101100_2+11000011_2$

10101111, No overflow

b) [10pts] $01001111_2-10110001_2$

10011110, Overflow

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Q4. (Circuit Design, 20pts) A car has a fuel-level detector that outputs the current fuel-level as a 3-bit binary number, with 000 meaning empty and 111 meaning full. Create a circuit that illuminates a "low fuel" indicator light (by setting an output L to 1) when the fuel level drops below level 3. Please show your work clearly including truth table, Boolean equation and circuit to get the full credit.

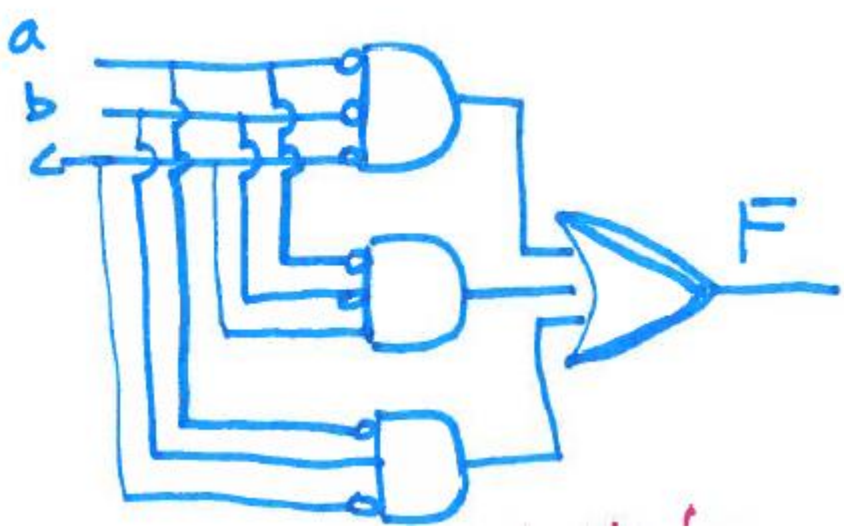
Solution:

The output is high ONLY when the fuel level drops BELOW 3.

a	b	c	Out (F)
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

$$F = a' b' c' + a' b' c + a' b\, c'$$

Logic Circuit Implementation:



You can simplify the equation to reduce the logic circuit complexity.

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Q5. (Performance, 20pts) (Computer Performance Assessment) Two compliers are used to compile the same benchmark program with the same instruction set architecture (ISA) for the same computer (clock rate=1GHz). There are three classes of instructions in this ISA, and each of them takes different numbers of clock cycles to finish. Class A instruction takes 2 clock cycles to finish, Class B instruction takes 3 clock cycles to finish, and Class C instruction takes 4 clock cycles to finish. The numbers of instructions generated by complier 1 and complier 2 are listed below.

	# of Inst. Generated by Compiler 1	# of Inst. Generated by Compiler 2
Class A (CPI = 2)	5 Millions	1 Millions
Class B (CPI = 4)	2 Millions	2 Millions
Class C (CPI = 3)	1 Millions	4 Millions

The following equation might be helpful:

$$\frac{\text{seconds}}{\text{program}} = \frac{\text{Insructions}}{\text{program}} \times \frac{\text{cycles}}{\text{Instructions}} \times \frac{\text{seconds}}{\text{cycle}}$$

$$= \mathit{Instruction\ Count} \times \mathit{CPI} \times \mathit{Clock\ C}\text{ycle Time}$$

a) Which compiler makes faster machine code (You must write down your calculation)? [10pts]

Compiler 1: (2*5+4*2+3*1)*10^6/10^9=0.021 second

Compiler 2: (2*1+4*2+3*4)*10^6/10^9=0.022 second

Compiler 1 is faster

b) If processor A has a higher clock rate than processor B, and processor A also has a higher MIPS (millions instruction per second) rating than processor B, explain whether processor A will always execute faster than processor B. Suppose that there are two implementations of the same instruction set architecture. Machine A has a clock cycle time of 20ns and an effective CPI of 1.5 for some program, and machine B has a clock cycle time of 15ns and an effective CPI of 1.0 for the same program. Which machine is faster for this program, and by how much? Assume that instruction count (IC) are the same for machine A and B. [10pts]

Solution:

The CPU Time is given by the equation:

CPU Time = Instruction count * CPI * Clock cycle Time

MIPS rating is defined by:

MIPS = (Clock Rate)/(CPI * 10^6)

For machines A and B:

$(\text{CPUTime})_A = (\text{Instruction count})_A * (\text{CPI})_A * (\text{Clock cycle Time})_A$

$(\text{CPUTime})_B = (\text{Instruction count})_B * (\text{CPI})_B * (\text{Clock cycle Time})_B$

$(\text{MIPS})_A = (\text{Clock Rate})_A/((\text{CPI})_A * 10^6)$

$(\text{MIPS})_B = (\text{Clock Rate})_B/((\text{CPI})_B * 10^6)$

If clock rate of A is higher than that of B, and MIPS rating of A is higher than that of B,

$(\text{MIPS})_A > (\text{MIPS})_B$ and $(\text{Clock Rate})_A > (\text{Clock Rate})_B$

From the above equations it follows that:

$(\text{Clock Rate})_A / (\text{Clock Rate})_B > (\text{CPI})_A / (\text{CPI})_B$

$(\text{Clock Cycle Time})_B / (\text{Clock Cycle Time})_A > (\text{CPI})_A / (\text{CPI})_B$

From this it emerges that if the instruction counts are the same, processor A will always execute faster than processor B.

Assuming instruction counts are the same,

$(\text{CPUTime})_A = (I) * 1.5 * 20\text{ns} = (I)*30\text{ns}$

$(\text{CPUTime})_B = (I) * 1.0 * 15\text{ns} = (I)*15\text{ns}$

Machine B is faster by twice as much as Machine A.

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